INCREASING AND STABILIZING FLUORIDE-FREE WATER CONSUMPTION WITH BEHAVIOR CHANGE CAMPAIGNS

Abhandlung
zur Erlangung der Doktorwürde
der Philosophischen Fakultät
der
Universität Zürich

vorgelegt von
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Angenommen im Herbstsemester 2012 auf Antrag von
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Herrn Prof. Dr. Heinz Gutscher

Acknowledgements

This doctoral thesis is part of the Water Research Quality (WRQ) project at Eawag (the Swiss Federal Institute of Aquatic Science and Technology) and results from the interdisciplinary collaboration between Eawag, the University of Zurich, Addis Ababa University, Oromo Self Help Organization (OSHO), Swiss Interchurch Aid (HEKS), and the Catholic Diocese of Nakuru (CDN). The project's findings acknowledge contributions from the Swiss National Science Foundation (SNF), the Swiss Agency for Development and Cooperation (SDC/DEZA), and the Swiss Interchurch Aid (HEKS).

First of all, I would like to express my deepest gratitude to my supervisor and mentor, Prof. Hans-Joachim Mosler, for choosing me and having confidence in me to take over this position. I would like to thank Professor Mosler for the great support throughout the whole project, for encouraging me during difficult situations, for always having an open ear, and for his many valuable inputs. I appreciated his interesting discussion. I am humbled by his trust in me and my work. I greatly appreciate his fatherly manner of protecting all his PhD students/sheep like a proud shepherd. I would also like to thank Robert Tobias, who was the perfect component and balance to my boss because he always criticized my work, triggered my thinking capabilities, and gave me constructive advice. At Eawag, I also want to express my sincere gratitude to all my colleagues of the SIAM department, who became friends, advisors, and supporters. Above all, my special thanks to Jennifer Inauen, my office colleague and hybrid friend. She always knew how to cheer me up, how to handle my moods and my strange noises in the office, and was always very helpful in providing input and in helping me solve problems of all kinds. I am also deeply indebted to my project colleague, Lars Osterwalder, for his technical input, his patience, his diplomacy, and his friendship.

At the University of Zürich, in the Social Psychology Department, I would like to acknowledge, with gratitude, the enthusiastic supervision of my co-supervisor, Prof. Heinz Gutscher. He aroused my interest in social psychology. I am also grateful to my students: Sarah Bhend, Zoe Röösli, Ina Sonego, and Anna Gamma. Without their work and commitment before and after fieldwork, the realization of this project would not have been possible. I am very proud of each of them.

In Ethiopia, where I spent half of my PhD time, I immediately felt at home, accepted, and supported. This is due to all my partners and colleagues in the field: Feyisa Lemma, Esayas Samuel, and Abebe Kiros from OSHO; Belay Kebede, Meron Belayneh, and Selamawit Tedesse from HEKS Ethiopia; Eyobel Mulugeta and Dr. Feleke from AAU;

and my interview team. Most of all, my friends and family in Addis Abeba made me feel at home. My thanks to: Ramy, Biruh, Omar, Glory, Eyobel, Quentin, Mekay, and of course Kalifa, Taco, Frodo and Sam.

Last, I would like to express my deepest thanks to my family and friends. I want to thank my wonderful mom for hosting me during the writing of this thesis, and for providing me with food, support and lots of love. I also want to thank: all my parents, my brother Marco and my friends: Kate, Jasmin, Anne-Catherine, Sabrina, Andrea and Jenny. They are always there for me, no matter where I am. A deep thanks to my partner, Ramy, for believing in me, for his patience, love and support, especially during many sleepless nights during the last phase. My deepest gratitude goes to my best friend, Bettina Muheim. Without her unlimited optimism, her endless encouragement, and unconditional love, I would have never come so far.

For Bettina
your doctorita

Summary

The occurrence of high fluoride concentrations in drinking water all over the world leads to the risk of developing dental and skeletal fluorosis. In Ethiopia, around 14 million people depend on water sources with excessive fluoride. As medical treatment of fluorosis is difficult and mostly ineffective the prevention of fluoride uptake becomes crucial. Implementing fluoride-removal community and household filters are one way to prevent people's fluoride intake. However, the mere provision of such filters is often not enough to change people's behavior towards drinking water. Different behavior change models from four disciplines are discussed in this thesis and related to the *RANAS* (risk, attitude, norm, ability, self-regulation) model of behavior change. Further the *RANAS* model is applied to explain the applied behavior change interventions in the following studies.

Study 1 investigated the usage of fluoride-removal household filters in four project areas in the Ethiopian Rift Valley. The study examines possible predictors of consuming filtered water derived from various behavior change theories. In a complete cross-sectional survey, 160 filter users were interviewed through structured face-to- face interviews. A logistic regression was carried out to reveal factors predicting consumption of filtered water. The results show that the consumption of fluoride- free water is mainly related to people's pride in offering filtered water to guests (status norm) and the feeling of being able to produce enough water with the filter (perceived behavioral control). Moreover, the study showed that the more filter users like the taste of filtered water and the more expensive they perceive the filter media, the more likely users will exclusively consume filtered water (attitudinal beliefs). Furthermore, perceiving the act of filling as a matter of habit (perceived habit) enhances filtered water consumption.

Based on these results psychological interventions were designed, implemented and evaluated in Study 2. The aim was to determine whether the distribution of the filters as a technical intervention is sufficient to ensure their sustainable usage or if additional psychological interventions for behavior change are necessary. In addition to the technical intervention two more intervention phases were introduced. In phase 1, a planning and social prompt intervention was introduced, and in phase 2, a workshop and public commitment intervention was applied. The longitudinal study evaluated three measurement times. The main results of Study 2 were (a) that only implementing a filter without applying a psychological intervention does not lead to sustainable behavior change, and (b) that the designed interventions were successful in increasing fluoride-free water consumption.

Study 3 investigated the usage of an implemented fluoride-removal community filter, based on the Nakuru technique (bone char and contact precipitation). Despite having access to the filter, the community used the filter sparingly. Therefore, a baseline with 173 face-to-face interviews was conducted to identify factors that enhance or hinder the consumption of filtered water. Further, a behavior-change campaign was implemented that used two types of interventions. On the one hand, a traditional non-evidence-based education intervention targeting health issues was used. On the other hand, based on the survey data, the intervention with the highest effect expectation was selected: persuasion regarding the perceived costs. The interventions were tailored to the households' characteristics—again using a traditional approach based only on demographic information (having children vulnerable to contracting fluorosis) and an evidence-based approach based on psychological data (high perceived costs). The analysis of the campaigns showed that the evidence-based intervention (persuasion on costs) was able to increase people's fluoride-free water consumption and to decrease people's perceived costs. Moreover, the intervention that was tailored to the target group was more effective in changing behavior than the intervention that did not fit the household's needs.

Study 4 aimed to further evaluate the usage of the implemented community filter after a second intervention phase. For the second intervention a personalized reminder was distributed to change people's behavior and increase the usage of the in-village community filter. During this promotion phase, an alternative fluoride-removal option (reverse osmosis plant) was installed in a neighboring village. This study examines psychological factors that explain the differences in preference between the two options and their influence on the usage of the different sources. In addition, the effectiveness of the applied behavior change technique, a personalized reminder, on the use of the in-village community filter was analyzed. In a complete longitudinal survey, 180 households, with access to both mitigation options, were interviewed through structured, face-to-face interviews. Logistic regressions were carried out to reveal factors predicting the usage of the two mitigation options and the effect of the implemented behavior change intervention. The results showed that four factors significantly predicted the preference between the two options: perceived vulnerability, perceived costs, taste and effort. Further, the implemented reminder was able to bind people to the in-village community filter and therefore to the more sustainable option. Based on the found results, possible recommendations for practitioners and researchers are made to help plan and implement mitigation options.

Study 5 presents an approach to designing community interventions based on evidence from quantitative data. After installing a new community filter based on aluminum oxyhydroxide, a baseline study was conducted in 211 households to evaluate the acceptance and usage of the filter. The first step was to identify important psychological factors, according to the *RANAS* model, that lead to behavior change. Further, descriptive statistics were calculated for behavioral determinants, and their influence on consumption was analyzed with a linear regression. As a last analytical step, an intervention potential was calculated for each behavioral factor. It was found that perceived distance, factual knowledge, commitment, and taste strongly influenced participants' consumption behavior and therefore should be tackled for interventions.

Summarizing, the *RANAS* model of behavior change described the usage of fluoride-removal techniques successfully. However, the presented studies also showed the need for including additional factors into the model or dividing certain factors into more detailed beliefs. The most important findings of this thesis are that (a) formative research and baseline studies are crucial to gain knowledge about key factors enhancing behavior change and to further design evidence-based interventions, (b) it is important to accompany technical interventions with psychological techniques to successfully change behavior, and (c) interventions that are tailored to the target group were found to be more effective as interventions that do not tackle the target group's needs. All in all, the five studies help to improve successful implementation and sustainable use of fluoride mitigation options so that the uptake of contaminated water can be prevented and the prevalence of fluorosis can be decreased.

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Introduction

Worldwide, 783 million people still rely on unimproved drinking water sources. They are, therefore, at high risk of developing water-born diseases, which lead to higher child mortality or very low life expectancy (UNICEF and World Health Organization, 2012). In most developing countries, the number one cause of death is diarrheal diseases resulting from a lack of safe drinking water, sanitation and hygiene. Even though most water-borne illnesses are directly related to microbiological contamination, other water contaminants should not be underestimated. In the world, the health of hundreds of millions of people is affected by geogenic contamination (UNICEF and WHO, 2012). One of the most widespread geogenic contaminants is fluoride. Elevated fluoride concentrations naturally occur in ground and surface water due to seismic activity and volcanic rocks. High fluoride concentrations were presumed in various countries including: India, China, Argentina, Mexico, and in several African countries (Amini et al., 2008). The consumption of water with excessive fluoride leads to a high risk of fluorosis. Dissolved in water and consumed, fluoride develops its toxic effect on the human body by penetrating the calcium-rich body parts (McDonagh et al., 2000). Over 70 million people worldwide suffer from fluorosis (Fawell et al., 2006) making fluorosis one of the most serious endemic health problems associated with natural geochemistry.

In Ethiopia, most of all in the Great Ethiopian Rift Valley, 8.5 million people rely on drinking water that is contaminated with excessive fluoride concentrations and are therefore at risk of developing dental and skeletal fluorosis (Tekle-Haimanot et al., 2006). Dental fluorosis (see Figure 1) is a disruption of the formation of dental enamel and results in irregular brown patches on teeth, tooth decay and, eventual tooth loss (Abanto et al., 2009). The symptoms of skeletal fluorosis (see Figure 2) are: joint pain, malformation of bones, limitation of joint movements, and crippling in the final stage of the disease. Besides its obvious physical impact on the Ethiopian population, fluorosis also has social and psychological consequences. These include: social exclusion, limited marriage possibilities, low wellbeing, and discrimination (Tekle-Haimanot, 2005).

The World Health Organization (2004) set the maximum level of fluoride in drinking water at 1.5 mg/l. As fluoride can also be taken up by other sources such as food, tea, and dental products and because the treatment of fluorosis is very difficult and ineffective, it is crucial to prevent fluoride intake (Malde, Scheidegger, Kare & Bader, 2011). In order to prevent people from consuming fluoride-contaminated water, it is vital to supply fluoride mitigation options.

Figure 1: Girl with dental fluorosis **Figure 2: Men with skeletal fluorosis**

Fluoride-removal options

Presently, a considerable number of fluoride mitigation options are available. The most commonly used in developing countries are fluoride-removal filters based on: bone char, contact precipitation, Nalgonda technique, Activated Alumina, and reverse osmosis (Fawell et al., 2006). Some of these mitigation options are more appropriate than others. It depends on such factors as: the implementation location and situation (e.g. fluoride contamination levels, raw water sources, cultural acceptability, infrastructural conditions). For the present five studies, two fluoride-removal techniques were implemented: filters using the Nakuru technique and Aluminum oxy-hydroxide.

The Nakuru technique uses a combination of bone char (charred animal bones) and calcium phosphate pellets (contact precipitation) as filter media (Korir et al., 2009). This technique has been developed and implemented in Kenya by the Water Quality section of the Catholic Diocese of Nakuru (CDN). Bone char filtration is regarded as an efficient, simple, and low-cost method. It can be applied on at the household and community level. The method is especially applicable in semi-arid rural areas that lack alternative fluoride-free water sources such as rainwater harvesting or piped water supply (Kloos & Tekle-Haimanot, 1999).

The filter material aluminum oxy-hydroxide (AO) is a mixture of aluminum sulfate and sodium hydroxide developed by a chemical research team at Addis Ababa University.

Household filters

The household filters, which were used in studies 1 and 2, are based on the Nakuru technique. The filter design consists of a two-bucket system. A smaller ten-liter bucket, on the top, contains two liters of sand designed to remove turbidity. The lower thirty-liter bucket contains the filter media for fluoride removal. A tap, connected to the lower bucket, is installed as an outlet for the filtered water. A household filter (lower bucket) is displayed in Figure 3 (lower bucket) and Figure 4 (complete filter).

Figure 3: Lower bucket with media

Figure 4: Complete two-bucket filter with tap

Community filters

Studies 3 and 4 focus on the usage of a fluoride-removal community filter using the Nakuru technique (see Figure 5). The community filter consists of two treatment tanks (containing 600 liters of bone char and 900 liters of calcium-phosphate pellets) and one storage tank for fluoride-treated water. For water collection, three taps were installed. The raw water inlet is from the nearby piped water supply containing 3 mg/L of fluoride.

Figure 5: Community filter with Nakuru technique

Figure 6: AO community filter

For study 5, a fluoride-removal community filter using aluminum oxy-hydroxide (AO) was implemented (see Figure 6). The filter design is very similar to the other community filter, also consisting of two treatment tanks (filled with 805 liters of AO media) and a storage tank for treated water. The filter is connected to a windmill for raw water inlet, which contains approximately 9 mg/L of fluoride.

Theoretical background

When practitioners, implementers and non-governmental organizations (NGOs) want to implement a new technology or a new device to increase people's health conditions regarding water, sanitation, and hygiene, they expect people to adopt, accept, and use this new technology. However, this is often not the case. With the implementation of a new device, people must change old behaviors, e.g., consuming contaminated raw water, to a new behavior, using the new device habitually. There are three main reasons why psychological research is necessary for successfully implementing new technologies: (1) A behavior change must be performed. (2) A behavior change process has underlying psychological factors that must be understood. (3) To change these factors, psychological intervention techniques must be developed and applied.

Behavior change

The understanding of behavior change has been the subject of many researchers, especially within health, environmental and consumer psychology, in the past decades. The overall aim was to identify determinants and processes of behavior change in order to influence them. To date, there are great numbers of different behavior change theories and models. This makes it difficult to decide which is the best or most accurate to apply within a given context.

Mainly two groups of theories are differentiated: continuum models and stage models (Schwarzer, 2008). Continuum models try to identify behavior determinants while placing the individual along a continuum of behavior likelihood. The most famous continuum models are: *Theory of Planned Behavior* (Ajzen, 1991) and *Health Belief Model* (Becker, 1974). The weaknesses of continuum models, Schwarzer (2008) argues, are that they account better for behavior variance than behavior change processes and that volitional processes are neglected. Stage models, such as *Health Action Process Approach* (Schwarzer, 2008), however, focus more on the behavior change process and try to overcome the intention-behavior gap by including volitional processes. Stage models propose that individuals pass a sequence of qualitatively distinct phases when changing

their behavior. Therefore, different psychological factors are relevant in each different phase (*Transtheoretical Model*, Prochaska & DiClemente, 1983). Disadvantages of stage models are, for example, the uncertainty about the number of stages and the transition between stages during a behavior change process. In conclusion, both approaches have their advantages and, therefore, legitimacy in describing and understanding behavior change. Whereas, continuum models explain why a person shows a certain behavior, a stage model additionally enables the estimation of how sustainable behavior change is realized (Schwarzer, 2008).

For many behavior change researchers, choosing a theory out of this great number of models is particular challenging. As behavior change regarding safe water consumption, especially fluoride-free water, is not a very common research subject, it is necessary to examine different behavior change theories before deciding which model is most accurate for explaining behavior change concerning drinking water. In the following, theories and models from four different perspectives are depicted in detail: health psychology, environmental psychology, consumer behavior, and NGO work in developing countries.

Two of the most applied behavior change theories in health psychology are Becker's (1974) *Health Belief Model* (*HBM*) and Schwarzer's (2008) *Health Action Process Approach* (*HAPA*).

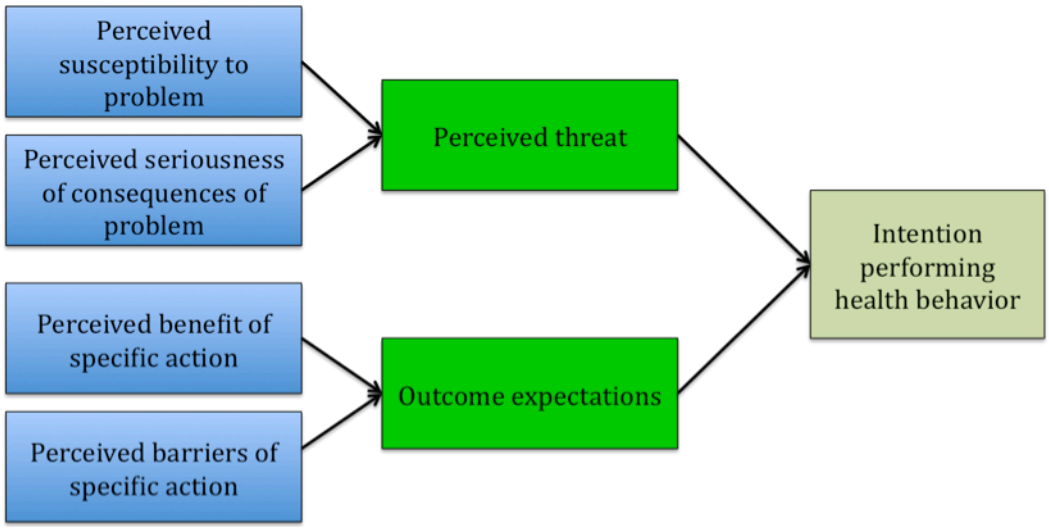

Figure 7: Health Belief Model (Becker, 1974).

The *HBM* (see Figure 7) was conceptualized in the fifties to find out why US citizens are not practicing preventive behaviors, e.g., cancer screenings. The focus lies, as the name proposes, on health-related beliefs. The model states that the intention to perform a certain health behavior is dependent on a person's perceived threat of an illness and the perceived outcome expectations if showing the health behavior (e.g., the effectiveness of

smoking cessation on prevention of lung-cancer). Further, perceived threat is influenced by a person's perceived susceptibility of contracting an illness without precaution and the perceived severity of the illness itself. The outcome expectancies of a person are dependent of a cost benefit analysis and the perceived barriers for performing the health behavior. A clear disadvantage of the model is the lack of the psychological predictor self-efficacy. Schwarzer (2008) and Ajzen (1991) postulate the importance of a person's perceived behavior control for predicting a health behavior. Moreover, the model explains only the behavioral intention not the behavior performance itself. This presents a problem, as many researchers found that a positive intention does not lead automatically to behavior (see Sheeran, 2002). However, the psychological factors depicted in the *HBM* were found to be very important predictors for different health behaviors. Therefore, the model essentially contributes to the behavior change research.

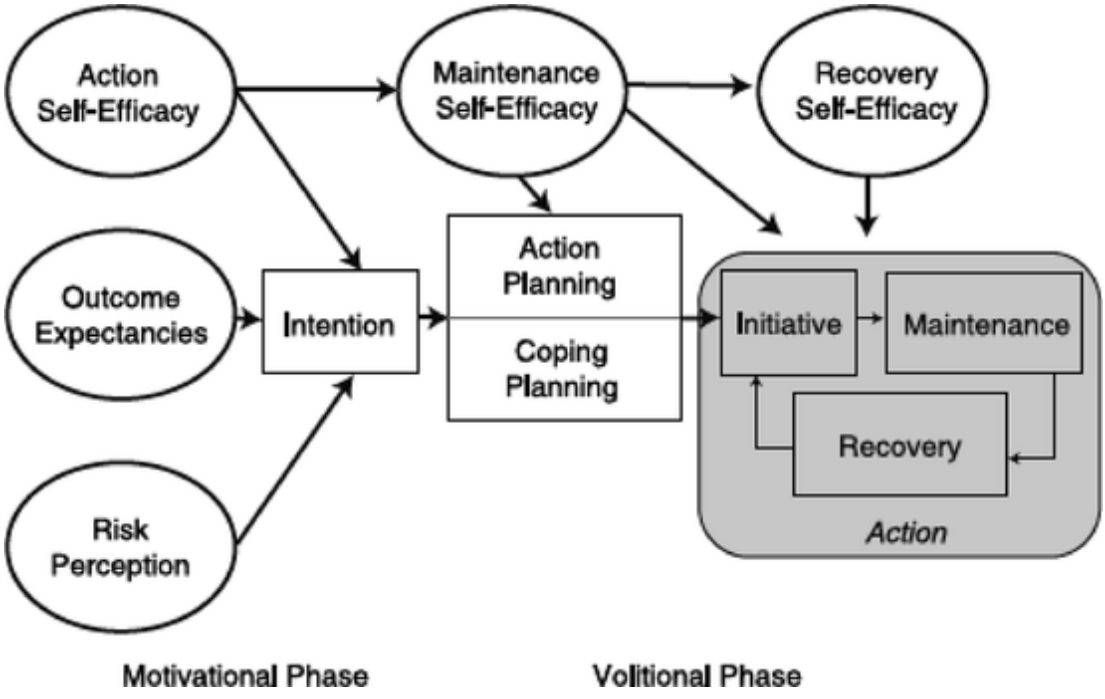

Figure 8: Health Action Process Approach HAPA (Schwarzer, 2008).

Ralf Schwarzer's *HAPA* (2008) originally integrated Bandura's *Social Cognitive Theory* (1986), the *Theory of Reasoned Action* (Fishbein & Ajzen, 1975) and the volitional theories of Heckhausen and his colleagues (e.g., Heckhausen & Gollwitzer, 1987). Contrary to the *HBM*, the *HAPA* (Fig. 8) tries to overcome the intention-behavior gap by describing the black box between intention and behavior performance. Schwarzer (2008) introduces two phases of behavior change: the pre-intentional motivational phase that leads to form a behavioral intention and the post-intentional volitional phase that leads to the

actual health behavior performance. During the initial motivational phase, an individual forms an intention depending on action self-efficacy, outcome expectancies, and risk perception. Schwarzer (2008) emphasizes that an intention cannot be formed if a person not only feels at risk of contracting an illness, but also needs to perceive outcome expectancies as positive and feels capable of performing the health behavior. Moreover, after an intention is built, the "good intention" must be transformed into instructions on how to act. If an action has been initiated, Schwarzer (2008) argues further, this behavior has to be maintained. Therefore, it requires self-regulatory skills (planning and self-efficacy). The discrepancy among the three stages of self-efficacy (action, maintenance, and recovery) was proven to be very useful (e.g., Scholz, Sniehotta & Schwarzer, 2005; Renner & Schwarzer, 2005). Also, the integration of planning as a post-intentional predictor for action was found to be important (e.g., Lippke, Wiedemann, Ziegelmann, Reuter & Schwarzer, 2009). All in all, the *HAPA* has served as a theoretical model for health behavior change successfully in many different studies. It was the basis for successful interventions in preventive health studies (e.g., Scholz et al., 2005; Renner et al., 2008).

One of the theories most often applied by environmental psychologist to explain behavior change towards a pro-environmental behavior is Ajzen's *Theory of Planned Behavior* (1991). Even though the *Theory of Reasoned Action* (Fishbein & Ajzen, 1975) was able to explain a considerable degree of variance between attitudes, norms, and intentions, one main intentional and behavioral determinant was missing: perceived behavioral control. Therefore, Ajzen (1991) developed the *Theory of Planned Behavior* (*TPB*). As shown in Figure 9, the TPB states that attitudes towards a certain behavior, what important others think about performing the behavior (subjective norm) and a person's perceived ability to perform the behavior, influence the intention to act and the behavior itself. Ajzen's TPB has been applied several times to understand behavior in a great range of different contexts. The meta-survey of Armitage & Conner (2001) demonstrated the application of the theory in 154 different contexts including: smoking cessation, health screening attendance, sexual behavior, internet use, consumer behavior, but also pro-environmental behaviors such as energy consumption, recycling behavior, and travel mode choice. Again, one drawback of this theory is the lack of explaining variance in the behavior itself. The model mainly explains behavioral intention. Therefore, in many studies the intention-behavior gap is still present and the black box remains (Armitage & Conner, 2001).

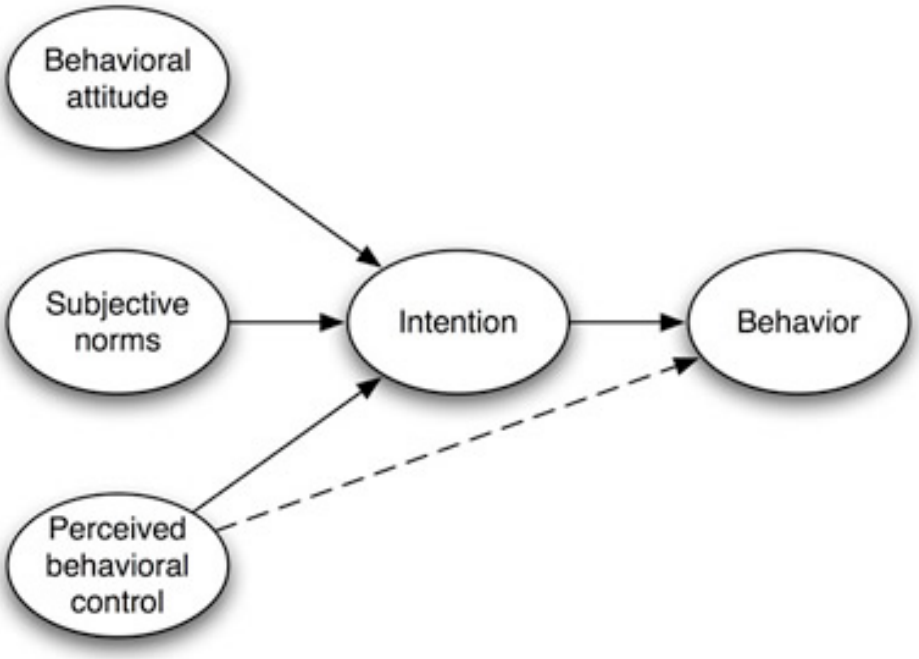

Figure 9: The Theory of Planned Behavior (Ajzen, 1991).

As the consumption of safe water is a consumer behavior, research on consumer psychology should be integrated into this chapter. One of the most widely used theories in marketing is the *Means-End Chain Theory* by Gutman (*MEC*, 1982). The *MEC* is a simple expectancy-value attitude model explaining consumer preferences and purchasing behavior (see Figure 10). The *MEC* assumes that consumer behavior is either consciously or unconsciously goal-directed. This means that consumers buy products to achieve certain goals. These goals are postulated to result from moral, personal or social values of a person (e.g., to feel happy, to protect one's family, to do something useful). These values are referred in the *MEC* as the "ends" that consumers aim at when buying a product. The "means" for achieving a consumer's goal are the benefits gained from consuming the purchased product and the perceived attributes of the product.

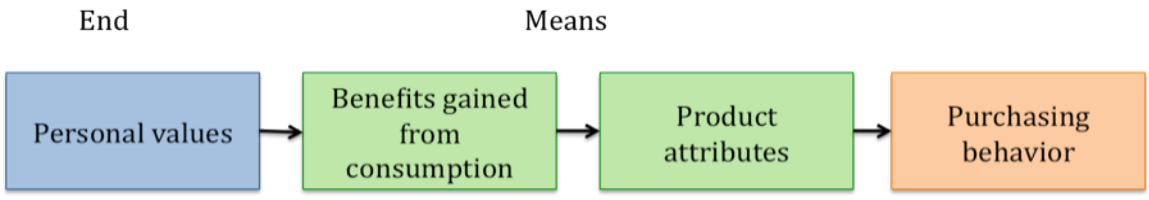

Figure 10: The Means-End Chain Theory (Gutman, 1982).

For example, bringing people to purchase safe water, according to the *MEC*, would imply identifying their values (e.g., protecting their children from the water-borne disease), showing them the benefits of consuming safe water (e.g., healthy children) and highlighting the positive attributes of the product (e.g., tastes good, is healthy). The *MEC* model is said to be much more qualified to provide understanding of consumer preference

than conventional consumer behavior theories. Moreover, it is applied widely to develop marketing campaigns of many different products (Reynolds & Olson, 2001). Even though the theory is also used for analyzing pro-social and environmental consumer decisions (e.g., Palmer-Barnes, Thompson & Thompson, 1999), it might fail to explain other behavior choices because of its lack of other important behavioral determinants.

In the area of development work, especially in the water, sanitation, and hygiene sector, organizations and practitioners come more and more to the conclusion, that behavior change is a key determinant of a successful development project. To date, there are a number of organizations, which developed behavior change frameworks. Two commonly known ones from the health sector are the *FOAM* and the *PSI* framework. The *Focus on Opportunity, Ability, and Motivation* (*FOAM*) framework was introduced by Coombes & Devine (2010) to analyze hand-washing behavior change and to design effective hand-washing programs for the Water and Sanitation Programme (WSP). The conceptual framework is displayed in Figure 11.

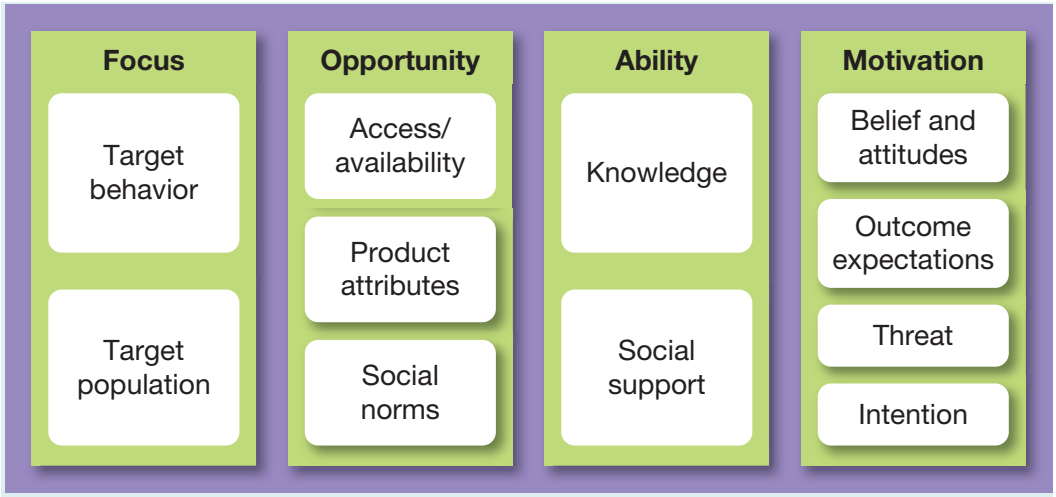

Figure 11: FOAM Framework (Coombes & Devine, 2010).

The *FOAM* framework was developed during a workshop, where participants reviewed the most common social cognition models and found that no model describes all the necessary determinants of hand washing behavior. Therefore, participants decided, by consensus, the most important behavioral determinants. Participants then assigned them to the categories: opportunity, ability and motivation. This classification system is often used for modeling consumer action or developing marketing campaigns (e.g., Ölander & Thøgersen, 1995). F (focus) includes the definition of the target population and the target behavior to be changed. O (opportunity) covers the resources individuals need to perform the target behavior. Determinants assigned at A (ability) describe a person's capability of performing the behavior and determinants of M (motivation) i.e., if the individual wants to

act. The difference from this framework to other behavior change models is that it also includes situational factors such as access/availability or sanctions/enforcement. Even though new aspects of behavior change are depicted in FOAM, important determinants are disregarded (e.g., self-efficacies) and other determinants are described vaguely (e.g., differentiating attitudes and beliefs from values and drivers). All in all, it is also not clear which or if all determinants should be used to stimulate to behavior change and whether all predictors should be tackled for the design of a campaign.

Further, the behavior change framework of *Population Services International* (*PSI*, 2004) is described. As shown in Figure 12, from button-up perspective, *PSI* is doing social marketing interventions (on the spheres of products, prices, and places) to influence behavioral determinants (the bubbles) to change the target group's risk reduction behavior or product or service use in order to improve people's health status and quality of life. The behavior determinant "bubbles" are classified again into the categories: opportunity, ability and motivation. As opportunity factors they describe institutional or structural factors that influence a person's chance to perform a behavior. Concerning ability, the framework includes "bubbles" that focus on an individual's skills or proficiencies needed to act. Motivation "bubbles" describe a person's desire to perform the promoted behavior. The *PSI* framework assumes similar behavioral determinants to the *FOAM* but adds a few predictors such as self-efficacy in ability and subjective norm, locus of control and willingness to pay to motivation. *PSI* also includes population characteristics as factors that can influence behavior but are, in their opinion, immutable by social marketing or promotion. These characteristics include: socio-demographics (e.g., age, status, and education), communication interactivity (e.g., media access, media use), experience (e.g., personal history with a given health problem), and personality traits (e.g. interpersonal trust). As already mentioned discussing the *FOAM* framework, the *PSI* also includes situational determinants. This fact definitely adds information to a behavior change process but might be much more difficult and expensive to change. To extend the social determinants with the subjective norm and social support instead of only focusing on the descriptive norm (social norm) will surely add variance to the explanation of behavior. Anyhow, social support is described in the framework as "given" social support whereas current studies found out that perceived received social support mainly facilitates behavior change (e.g., Scholz, Knoll, Rolgas & Gralla, 2009).

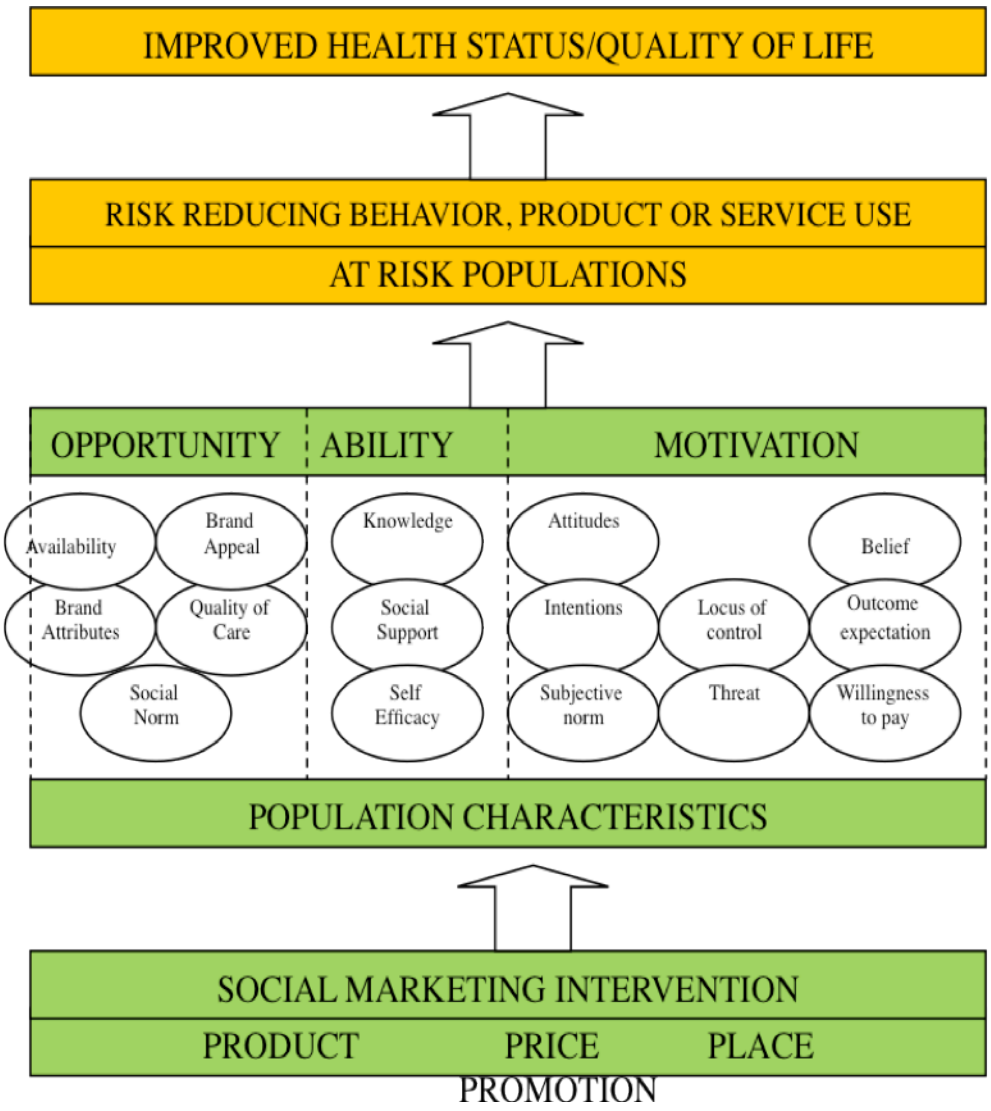

Figure 12: PSI behavior change framework (PSI, 2004).

The review of the listed behavior change approaches still reveals several shortcomings. Except for Schwarzer's (2008) *HAPA*, all described approaches clearly lack self-regulation factors (e.g., planning, action control) and ability factors that describe a person's perceived ability to perform and also maintain a behavior change (self-efficacy). Even though all theories, models, and frameworks are potentially useful within the parameters that the theory describes, it is challenging for researchers and implementers to find the accurate theory for the given health problem. This implies the need for a multi-theory approach (Bartholomew, Parcel, Kok & Gottlieb, 2006).

For all five studies, the *RANAS* (risk, attitude, norm, ability, self-regulation) model (Mosler, 2012) was taken into account because it: a) is derived from health and social psychological theory (e.g. Ajzen, 1991; Schwarzer, 2008), b) integrates aspects of several theories conceptually, c) comprises all factors to explain behavior change (Albarracín et al., 2005), and d) provides behavior change interventions, which correspond to the psychological factors to be changed. In the *RANAS* model (see Figure 13), behavioral

factors are assigned to five different factor blocks: risk factors, attitude factors, norm factors, ability factors, and self-regulation factors.

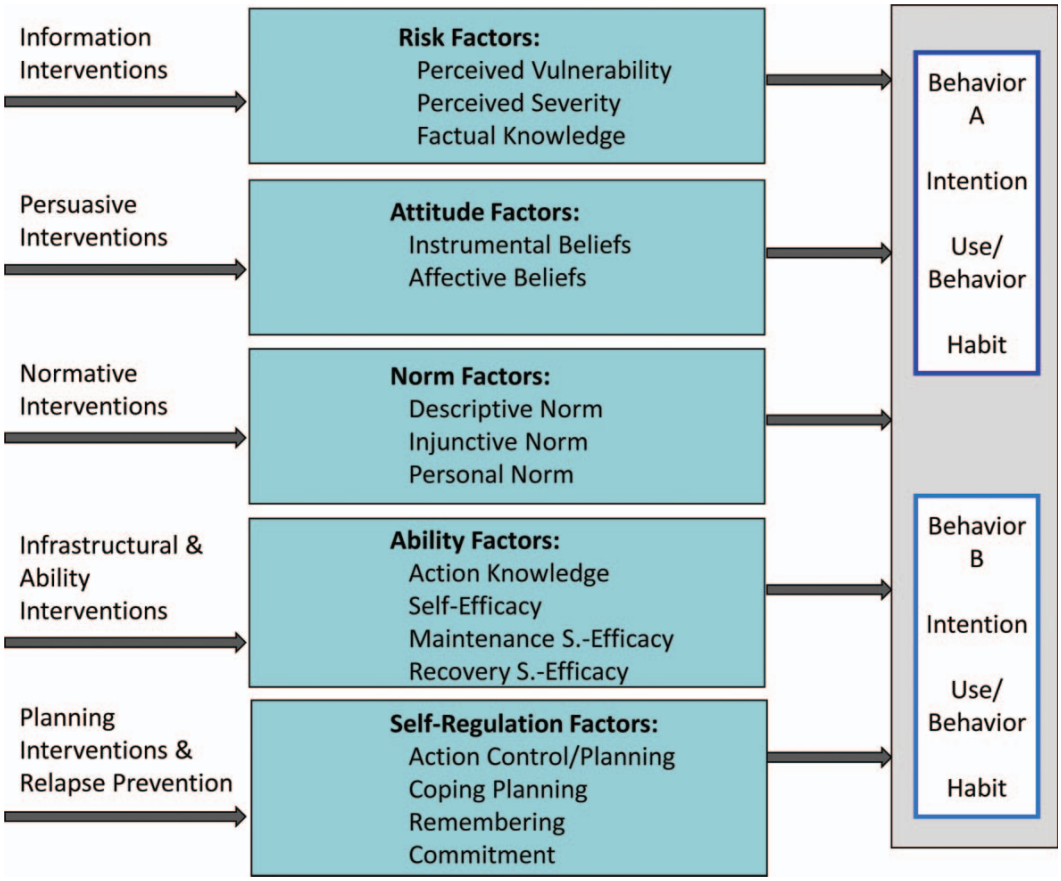

Figure 13: The RANAS Model of behavior change (Mosler, 2012).

As risk factors, the model presents a person's perceived vulnerability to contract an illness, the perceived severity of the illness, and factual knowledge about the disease and its prevention. The attitude factors are divided into: instrumental beliefs (e.g., perceived costs, perceived effort, and benefit) and affective beliefs (e.g., feelings that arise when performing or thinking about the behavior). The most behavior influential norm factors are descriptive norm (what others normally do), injunctive norm (what important others think I should do) and personal norms (what I personally believe I should do). Further, the RANAS model lists ability factors, which are represented by the knowledge of how to perform a behavior, the perceived ability to: perform a behavior (self-efficacy), maintain a behavior (maintenance self-efficacy) and restart a behavior after having stopped or relapsed into old habits (recovery self-efficacy). A further very important factor block, which should be in favor of the target behavior in order to achieve behavior change, is the self-regulation block.

Self-regulation factors help an individual to manage conflicting goals or upcoming barriers, which hinder behavior performance and maintenance. Action control is a person's

constant evaluation of the performed behavior, whereas action planning describes a person's plan when, where and how to initiate the behavior. Another self-regulation factor is coping planning. This is defined as an individual's plan of how to overcome presumed barriers. The last two self-regulation factors, addressed in none of the previous behavior change approaches, are remembering and commitment. Tobias (2009) states that, in order to perform a behavior change, an individual has to remember the behavior during the accurate moment of action and, moreover, has to feel committed to perform the target behavior. Hence, one main aspect of how the *RANAS* differs from the other approaches is the introduction of self-regulation factors, especially commitment and remembering. Another aspect that is different in the *RANAS* model is, as Mosler (2012) states, that while analyzing behavior changes it is not only important to evaluate the targeted behavior A (e.g., consuming safe water) but also to examine the alternative or old behavior B (e.g., consuming raw water). Further, the *RANAS* model assumes that the psychological factors determine not only the different behaviors but also the use of new technology, behavioral intentions, and habits.

In order to provide a rationale for why the *RANAS* model was chosen for the present studies, all described behavior change approaches are listed in Table 1 comparing its behavior determinants with the factors from the *RANAS* model. The examination of the table makes clear that the Becker's (1974) *HBM* covers very few aspects of behavior change and of the *RANAS* model, whereas Schwarzer's (2008) *HAPA* seems to conceal almost all behavioral determinants also depicted in the *RANAS* model. However, while the *HAPA* remains vague with the description of outcome expectancies, the *RANAS* is much more detailed in explaining attitudinal and normative factors, which Schwarzer might all consider as his outcome expectancies.

Ajzen's (1991) *TPB* includes neither risk factors nor self-regulation factors to explain behavior. Further, Ajzen (1991) includes only perceived behavioral control within the ability factors. It neglects a person's perceived ability to maintain a behavior or recover a relapse. Also from the point of view of consumer behavior research, Gutman's *MEC* theory (1982) neglects many important behavior determinants and focuses mainly on attitude factors. Even though the behavior change frameworks *FOAM* and *PSI* include new aspects in their conceptual models, Table 1 also reveals the fact that both approaches concentrate mainly on attitude or motivational factors. Moreover, *FOAM* completely disregards ability and self-regulation factors for explaining behavior change.

Table 1: Overview of all described behavior change approaches compared with the factors of the RANAS model

RANAS		HBM	HAPA	TPB	MEC	FOAM	PSI
Risk factors	**Perceived vulnerability**	Perceived susceptibility	Risk perception	-	-	Threat	Threat
	Perceived severity	Perceived seriousness		-	-		
	Factual knowledge	-		-	-	Knowledge	Knowledge
Attitude factors	**Instrumental beliefs**	Outcome expectancies	Outcome expectancies	Attitude	Product attributes, benefits of consumption	Product attributes, outcome expectation, belief & attitudes	Brand attributes, brand appeal, attitudes, belief, outcome expectation
	Affective beliefs						
Norm factors	**Descriptive norm**			-		Social norms	Social norms
	Injunctive norm			Subjective norm		-	Subjective norm
	Personal norm			-	Personal values	-	-
Ability factors	**Action knowledge**	-	-	-	-	Knowledge	Knowledge
	Self-efficacy	-	Action Self-efficacy	PBC	-	-	Self-efficacy
	Maintenance self-efficacy	-	Maintenance self-efficacy	-	-	-	-
	Recovery self-efficacy	-	Recovery self-efficacy	-	-	-	-
Self-regulation factors	**Action control / planning**	-	Action planning	-	-	-	-
	Coping planning	-	Coping planning	-	-	-	-
	Remembering	-	-	-	-	-	-
	Commitment	-	-	-	-	-	-

The *PSI* framework at least includes self-efficacy within the opportunity factors but focuses only on action self-efficacy. As well as most of the other approaches, the *PSI* behavior change framework does not include self-regulation factors at all. However, both *FOAM* and *PSI* introduce social support in their models. This has been shown, in recent health behavior studies, to be an influential factor in facilitating behavior change and can be tackled with behavior change interventions (Schwarzer & Knoll, 2010). Perceived, received, and provided social support could be integrated into the RANAS model within the ability factors. This addition might result in better understanding of the behavior change process.

In conclusion, the *RANAS* model of behavior change describes psychological factors of different aspects of behavior change, combining multiple theories and including determinants from diverse areas of psychology. Even though all separate factors of the *RANAS* model can be found in literature to be influences on behavior, no other theory or approach itself combines all the important factors in one conceptual model. A further, very important advantage of the *RANAS* behavior change model is the inclusion of which behavior-changing interventions positively influence which psychological factor blocks. In order to design appropriate and successful health promotion campaigns, it is necessary to understand the behavior change process of the underlying health problem and to know how the influential psychological factors can be influenced with interventions.

Behavior change interventions

Implementing a new technology or providing people with new devices is not enough to convince people to use these technologies because it requires a behavior change. To change a target population's behavior, profound knowledge of influencing psychological factors is necessary in order to develop behavior change interventions. As has been described above, there are a great number of underlying psychological factors, which can impede or encourage a person to change a behavior. While in many developing countries considerable achievements have been made to provide low-income people in remote areas with safe drinking water or proper sanitation facilities (e.g., providing arsenic mitigation options in Bangladesh, or fluoride-free water options in Ethiopia), there are still millions of people who remain at risk of developing a water borne disease (Mosler, Blöchlinger & Inauen, 2010). One reason for this is the lack of usage of these mitigation options and the missing behavior change of potential users. Tobias and Berg (2011) state that, compared to the effort invested in the development of technical solutions, very little

effort is spent on changing the targeted individual's behaviors. The importance of developing effective interventions to change human behavior is required in different areas such as: health preventive and pro-environmental behavior change (e.g., Michie et al., 2005; Abrahamse, Steg, Vlek, & Rothengatter, 2005).

To date, a great number of behavior change techniques (BCTs) exist and were applied, more or less successfully, in many studies. In a review, Michie and her colleagues (2008) identified 118 techniques applied in health-related behavior studies. Because of this great number of different BCTs, it is advisable to categorize the techniques. However, Abraham and Michie (2008) emphasize the problem of categorization of intervention contents because a standardized vocabulary that defines intervention components has not been yet developed. The authors, nevertheless, mapped BCTs, assigning them to twenty-six different categories. However, Mosler (2012) defined five classes of BCTs and included them in the RANAS behavior change model, indicating which BCT class potentially influences which psychological factor block. The assignment was based on behavior change literature including: Bartholomew's intervention mapping approach (2006), the meta-analysis of Albarracin and colleagues (2005), and the intervention review of Michie and colleagues (2008). Further, Mosler (2012) describes possible BCTs for each intervention class. His approach makes it comparably easy for practitioners and implementers to choose a BCT for the behavior to be changed, if they know which underlying factors are the most influential. The five BCT classes of Mosler (2012) are presented in Table 2. Even though the BCT classes might not be specific enough for adopters of BCTs, the classification is logical and easy to understand. To further split these classes, as done by Abraham and Michie (2008), makes the process of choosing a BCT more complicated and risks making the study not even remotely comprehensible.

Table 2: BCT classes, corresponding factor blocks and BCT examples (Mosler, 2012)

BCT class	Influenced factor block	BCT example
Information BCTs	Risk factors	Knowledge transfer
Persuasive BCTs	Attitudinal factors	Persuasive arguments
Normative BCTs	Norm factors	Public commitment
Infrastructural and ability BCTs	Ability factors	Guided practice
Planning BCTs and relapse prevention	Self-regulation factors	Prompts

However, on one point, most of the behavior change researchers fully agree: All behavior change interventions should be theory-based (e.g., Hill. Abraham & Wright, 2007; Michie et al., 2008; Mosler, 2012). Michie and her colleagues state that "only when

we know which techniques change which theoretical constructs and processes we will be able to optimally apply our theories to design interventions, and to use the results of intervention evaluations to refine our theories" (2007, pp. 251-252). Moreover, the same authors claim that there is an increasing recognition that interventions to change human behavior should draw on theories of behavior change (2007). Further, it has been shown, in different studies, that theory-based interventions were most effective in enhancing behavior change (e.g., Hill et al., 2007).

The effectiveness of an applied behavior change intervention is one of the main subjects of change research. The question arises: How can BCTs be improved further to be more effective in changing people's behavior? One area of research that attempts to address this question is the area of tailored health communication. Tailoring is defined as "any combination of strategies and information intended to reach one specific person, based on characteristics that are unique to that person, related to the outcome of interest, and derived from an individual assessment" (Kreuter, Strecher & Glassman, 1999, p. 277). Also Petty and Cacioppo's (1986) *Elaboration Likelihood Model* states that individuals are more likely to actively and thoughtfully process information, if it is perceived to be personally relevant. Kreuter and colleagues (1999) assume that the best way of delivering tailored health messages is through face-to-face counseling. This method can provide immediate feedback. The contact makes the message delivery more personal. However, the effort and costs of personal visits are great and, therefore, the number of people to be reached remains small. On the other hand, Tobias and colleagues (2009) explain that, because of having limited funds, it is more advisable to select and implement only those intervention strategies that are most effective. Further, through the individualized information gained in the pre-intervention phase, people who already show the targeted health behavior do not have to be tackled anymore. In terms of the effectiveness of tailored health messages, several studies found promising results in changing health behaviors such as: smoking cessation, healthy diet, preventive screening, and physical activity (e.g., Prochaska, DiClemente, Velicer & Rossi, 1993; Campell et al., 1994).

Nevertheless, Bandura (2004) emphasizes the fact, that tailoring communications does not necessarily guarantee better outcomes. The effectiveness depends on the predictive value of the tailored factor. If the tailored message targets a weak or irrelevant factor, the tailoring will fail to induce a behavior change.

The importance of linking the BCTs to theoretical constructs is increasingly prevalent (e.g., Geller et. al., 1990; McKenzie-Mohr, 2000; Michie et al., 2008; Mosler,

2012). On the one hand, this is important because, when designing health interventions, the implementer has to know which psychological factors should be targeted to enhance behavior change. On the other hand, the evaluation of the success of an intervention should focus not only on the effectiveness on behavior but also on whether the tackled psychological constructs were changed. Hence, if the modes of operation of BCTs are analyzed, they further can be improved and can assist in the development of accurate interventions in the future.

In the following, four behavior change interventions are described. These were applied in Study 2, Study 3, and Study 4. Literature about the BCTs is discussed regarding: their modes of operation, their assignment to BCT classes, and their effectiveness. For an overview of all applied BCTs see Table 3.

Table 3: Overview of applied BCTs including their influencing factors, BCT classification and short- and long-term effectiveness

BCT	Influencing factors	BCT classification	Effectiveness*
Social prompt	- Remembering - Action planning - Self-efficacy	- Planning BCTs & relapse prevention - Ability BCTs	Short-term + Long-term +
Educational workshop	- Perceived vulnerability - Perceived severity - Factual knowledge	- Information BCTs	Short-term - Long-term -
Public commitment	- Descriptive norm - Subjective norm - Commitment	- Normative BCTs - Planning BCT & relapse prevention	Short-term + Long-term +
Persuasion	- Instrumental belief - Affective belief - Factual knowledge - Perceived vulnerability	- Persuasive BCTs	Short-term + Long-term -
Personalized reminder	- Remembering - Commitment	- Planning BCTs & relapse prevention	Short-term + Long-term -

Note. *Effectiveness: + = effect assumed, - = effect not assumed.

Study 2 applied two different intervention techniques in two different phases of a behavior change campaign: social prompts and an educational workshop with commitment. Prompts or reminders are visual or oral memory aids that point an individual toward a certain targeted behavior (Tobias, 2009). Where traditional prompts normally are implemented in the form of promotional material (e.g., stickers, posters), social prompts

involve an additional person. A person from the close social environment, optimally sharing the same household, acts as a constant reminder in order to help remember the target person to perform the target behavior. There are few studies, which used individuals as prompts. But, these studies engaged people to act as single prompts within a key situation – for example: single spoken prompts to increase seatbelt use (Gras, Cunell, Montserrat, Sullman and Oliveras, 2003) or speaking prompts from a cashier to decrease plastic bag use in supermarkets (Ohtomo and Ohuma, 2010).

Geller and colleagues (1990) describe a social prompt in their definition of BCTs as an oral activator, "an oral communication that attempts to prompt desired performance" (p. 130). A social prompt can also be seen as a form of informational or instrumental social support. Studies focusing on the influence of social support on health-related behaviors found that the more social support is received, the more likely a behavior is changed (e.g., Scholz et al., 2009; Boutin-Foster, 2005; Schwarzer & Knoll, 2010). A study attempting to increase medical adherence found that patients find it easier to take their medication when their partners help them remember (Boutin-Foster, 2005). In Study 2, the social prompt intervention was combined with an initial plan. The target person had to plan how many times and when during the day to perform the behavior. The plan was communicated to an additional person living in the household (normally a daughter). This person was requested to remind the target person to perform the behavior at the planned times. Prompts are assumed to have a positive influence on self-regulation factors, most of all on remembering to perform the target behavior (Tobias, 2009; McKenzie-Mohr, 2000). Combined with the initial planning, the prompt should also increase a person's action planning (Michie et al., 2008). If the behavior is not performed even though the 'social prompt person' reminds the target person to do so, cognitive dissonance - a feeling of discomfort because of two conflicting cognitions - arises in the target person (Festinger, 1957). In order to avoid the dissonance, the person has to act in the desired way. Perceiving the social prompt as support leads to the feeling of being more capable to perform the behavior and, consequently, to a positive influence on a person's self-efficacy (Scholz et al., 2012). Mosler (2012) classifies prompt BCTs as planning BCTs and relapse prevention because of their main effect on self-regulation factors planning and remembering. However, a social prompt in the form of social support also has effects on ability factors and therefore could also be classified as ability BCT.

The efficiency of prompts changing behavior has been widely tested. Most studies found positive effects of prompts (e.g. Geller, Farris & Post, 1973; Schultz, Oskamp &

Mainieri, 1995). De Young (1993) states clearly that a prompt's effect declines after a certain period of time because it loses its novelty. Moreover, he emphasizes that the effectiveness of a prompt depends on its wording, its location, and on the frequency of the prompt (De Young, 1993). However, Geller et al. (1990) found oral activators to have long-term effects.

In a second phase of Study 2, an educational workshop was implemented followed by a public commitment. The workshop aimed mainly to share factual knowledge regarding the causes, consequences, and prevention of the health risk with the target group. Providing information about a health problem – for example, information about HIV, lung cancer, or substance abuse - is a commonly applied BCT (see meta-analysis of Derzon and Lipsey, 2002). Informational campaigns, depending on content, can influence risk factors (perceived vulnerability and severity) and most of all have effects on knowledge (Mosler, 2012). Therefore, an educational workshop is classified as information intervention according to Mosler (2012). Information campaigns, even though conveying information successfully, do not necessarily lead to behavior change. Even if there are effects, these are often limited to short periods of time (Verplanken & Wood, 2006; Staats van Leeuwen & Witt, 2000). Moreover, it is stated by habit formation researchers that habits resist informational interventions (Verplanken & Wood, 2006).

It is assumed that promotion campaigns are more successful if they consist of multiple strategies (Gardner & Stern, 2002). Therefore, the educational workshop was combined with a public commitment. A public commitment or pledging induces individuals to make an oral or written commitment to a certain behavior in public (DeLeon & Fuqua, 1995). People who perform a public commitment or pledge make an internal decision to behave in a certain way and bind themselves to the target behavior (Oskamp et al., 1991; Kiesler, 1971). Several studies applied commitment interventions to change health or pro-environmental behaviors (e.g., Ludwig & Geller, 1991; Lokhorst, van Dijk, Staats, van Dijk & de Snoo, 2010; Boyce & Geller, 2000). The modes of operation of public commitment are diverse. Committing oneself in public induces social pressure. The pledge is socially visible (Schultz et al., 1995). Moreover, the commitment evokes a person's willingness to conform as individuals seek consistency between what they say and what they do (Zimbardo & Leippe, 1991). Festinger's (1957) cognitive dissonance theory explains this process with an individual's need for avoiding dissonant cognitions and seeking consistent cognitions. Inconsistency results in high social costs such as loss of trust or integrity. Moreover, a public commitment influences the descriptive and subjective

norms. People see how many important others perform the same behavior and, therefore, approve of the health behavior. As the commitment BCT influences various psychological factors, it is not easy to classify. However, because of its strong effects on social constructs, Mosler (2012) assigns the public commitment to the normative BCT class. Commitment interventions are generally seen as effective intervention techniques (e.g., Schultz et al., 1995; Abrahamse et al., 2005; Dwyer, Leeming, Cobern, Porter & Jackson, 1993). De Young (1993) states that commitment interventions are even able to create sustainable, long-term behavior changes.

Study 3 implemented a persuasion campaign targeting two different psychological behavior determinants: perceived vulnerability (risk factor) and perceived costs (attitude factor). The psychology and processes of persuasion have been studied extensively over recent decades (e.g., Petty & Cacioppo, 1986; Murphy & Alexander, 2004; Cialdini, 2001). Usually, applied persuasive communications present a standard behavior recommendation combined with information to persuade people following this recommendation (Albarracín et al., 2003). Most of the applied persuasion studies focus on changing the following persuasive factors: knowledge (e.g., Tormala & Petty, 2007), affective beliefs (e.g., Rucker & Petty, 2004), and most of all attitude (e.g., Beale & Bonsall, 2007). The modes of operation of persuasion campaigns depend fully on communication contents (Albarracín et al., 2003). After the main influencing behavioral determinants are identified, the persuasion campaign should be designed to target exactly these factors. In Study 3, the most promising factor for potential behavior change was perceived costs. Therefore, one persuasion campaign was designed to influence this instrumental belief. Additionally, a persuasion campaign was developed based on a common awareness creation approach using health-related messages targeting people's perceived vulnerability, a risk factor. As most persuasion BCTs focus on changing people's attitudes about a certain behavior, Mosler (2012) assigned them to the class of persuasive interventions. However, this classification also depends on the content. Even though positive effects of persuasion campaigns as BCTs were found (e.g., Hill et al., 2007; Albarracín et al., 2003), the meta-analysis of Albarracín and colleagues (2003) found that factual information and arguments to increase perceived vulnerability have little effect on behavior change. Unfortunately, to my knowledge, there is no study that analyzed persuasion on perceived costs. Therefore, the campaigns effectiveness is not known.

The last BCT applied in Study 4 is a personalized photo reminder. Again, the reminder acts as a prompt or memory aid to point a person to the targeted behavior

(Tobias, 2009). In Study 4, the reminder was a photo of its owner performing the desired behavior. Additionally, underneath the photo a slogan was added which prompted the target person not to forget to act. People who received a reminder were asked to place it somewhere in the household where it was easily visible. For a prompt to be successful, it should contain clear behavior messages and, further, should be situated at location where the behavior is normally initiated (Tobias, 2009). Reminders can be effective tools to encourage action as various behaviors are neglected simply because people forget them (McKenzie-Mohr, 2000). As already mentioned, discussing the social prompt BCT, a prompt or reminder influences most of the self-regulation factor remembering (Tobias, 2009). Moreover, a prompt can lead to an internal feeling of discomfort or dissonance if the behavior is not performed. This happens due to the emerging awareness of having two conflicting goals (Festinger, 1957). Because the reminder is personalized, the photo prompt might also lead to a higher commitment towards the prompted behavior. Even though there are no studies to date that evaluate personalized reminders, there are various studies in the field of environmental and health behavior that were able to show the effectiveness of prompts on behavior change (e.g. Austin, Hatfield, Grindle & Bailey, 1993; Eves & Webb, 2006; Reveiz & de Aguiar, 2009; Cox, Cox & Cox, 2005). The meta-analysis of De Young (1993) states that the effects of reminders on behavior change are not sustainable because a prompt looses its salience over time and is not noticed anymore. However, more recent studies have shown long-term effectiveness of prompts. Cox and his colleagues (2005) prompted seat belt use with simple signs. They found the effect on behavior to be stable over four years. All in all, reminders or prompts are very popular BCTs because costs and effort of producing and disseminating prompts are rather low and they are accepted by a wide cultural audience (De Young, 1993; Thyer & Geller, 1987).

Research questions

The following research questions incorporate the depicted behavior change techniques as well as the psychological influences on fluoride-free consumption behavior.

Study 1

- RQ1: What are the enhancing and hindering psychological factors of fluoride-removal household filter use?

Study 2

- RQ1: Is a technical intervention (providing a household filter) enough to induce behavior change or are additional psychological interventions necessary?
- RQ2: Does a social prompt lead to behavior change?
- RQ3: How does the social prompt psychologically operate?
- RQ4: Does an educational workshop followed by a public commitment lead to further behavior change?
- RQ5: How does the workshop with public commitment psychologically operate?

Study 3

- RQ1: Is it possible to change behavior only by changing subjective perceptions and beliefs even if the objective circumstances remain the same?
- RQ2: Does it pay off to design behavior-change campaigns based on evidence and to tailor interventions to the target group or apply an intervention only to a predefined selection of the population?
- RQ3: Are there differences among people who do not receive any intervention, people who receive inadequate interventions and people who receive an intervention that does not fit regarding changes in the target behavior?

Study 4

- RQ1: Which psychological factors determine the preference between two fluoride mitigation options?
- RQ2: How effective are personalized reminders to bind people to a more sustainable water option instead of changing to another less sustainable option?

Study 5

- RQ1: Which psychological factors influence people's fluoride-free water consumption at a newly implemented community filter?
- RQ2: Which are the psychological factors with the highest potential to be changed?

Study 1: Determinants of Exclusive Consumption of Fluoride-Free Water: A Cross-sectional Household Study in Rural Ethiopia

Abstract

Aim The occurrence of high fluoride concentrations in the ground- and surface water all over the world leads to the risk of developing dental and skeletal fluorosis. In Ethiopia, 8 million people depend on water sources with excessive fluoride. In four project areas in the Ethiopian Rift Valley, fluoride removal household filters based on bone char media have been implemented. This study examines possible predictors of consuming filtered water derived from various behavior change theories.

Subject and methods In a complete cross-sectional survey, 160 filter users were interviewed through structured face-to- face interviews. A logistic regression was carried out to reveal factors predicting consumption of filtered water.

Results The results show that the consumption of fluoride- free water is mainly related to people's pride in offering filtered water to guests (status norm) and the feeling of being able to produce enough water with the filter (perceived behavioral control). Moreover, the study showed that the more filter users like the taste of filtered water and the more expensive they perceive the filter media, the more likely users will exclusively consume filtered water (attitudinal beliefs). Furthermore, perceiving the act of filling as a matter of habit (perceived habit) enhances filtered water consumption.

Conclusion Based on the results, possible intervention strategies to change the influential psychological factors and, hence, increase the consumption of treated water can be designed.

Keywords: Fluoride removal filter, behavior change, status norm, perceived behavior control, attitudinal beliefs, habit

Introduction[1]

Approximately 200 million people worldwide rely on water sources contaminated with excessive fluoride. The probability of occurrence of high fluoride concentration in ground- and surface water was detected in various countries such as India, China, Argentina, Mexico, and in several African countries (Amini et al. 2008). In Ethiopia, especially in the Ethiopian Rift Valley, water contaminated with fluoride has led to serious public health problems (Kloos and Tekle-Haimanot 1999; Tekle-Haimanot 2005; Tekle-Haimanot et al. 2006).

Fluoride is mostly absorbed into the human body by drinking or cooking with water containing fluoride (Tekle- Haimanot et al. 2006). Excess fluoride intake can cause dental and skeletal fluorosis. Symptoms range from irregular brown patches on teeth to deformation of bones, limitation of joint movements, and even crippling (crippling fluorosis) in the last stage of the disease, accompanied by serious psychosocial impacts (Tekle-Haimanot 2005).

Out of a population of 10 million in the Ethiopian Rift Valley, 8.5 million people are exposed to high fluoride contamination (Tekle-Haimanot 2005). Medical treatment of the disease has been found to be difficult and mostly ineffective. Therefore, preventing high fluoride consumption becomes crucial.

Bone char filtration is an efficient, simple, and low-cost defluoridation technique, applicable at the household and community levels in semiarid rural areas lacking alternative water sources such as rainwater harvesting or piped water supplies. The filter material is charred animal bone that adsorbs fluoride (Kloos and Tekle-Haimanot 1999; Tekle- Haimanot 2005). Even though considerable achievements have been made in fluoride mitigation since the problem was first detected in urban areas, fluoride is still not removed effectively. In rural areas, the case is even worse, since only a few filter systems have been installed, and they are not sustained, mostly due to a lack of support and maintenance (Tekle-Haimanot 2005). Except for research on the medical consequences of fluoride (e.g., Malde et al. 2011; Wondwossen et al. 2006), little research has been conducted so far on the topic. As a result, the social, situational, and psychological determinants and consequences of filter use have remained unclear. Leading people to use

[1] This study is published: Huber, A. C., Bhend, S., & Mosler, H.-J. (2011). Determinants of exclusive consumption of fluoride-free water: a cross-sectional household study in rural Ethiopia. *Journal of Public Health,* 20, 269- 278.

safe water options implies more than just implementing new technologies; considering and analyzing the social, situational, and psychological factors of using a new technology are crucial. Studies focusing on the social and psychological aspects related to acceptance of bone char filtration as well as the identification of important factors that encourage the use of household filters have not yet been carried out. After implementing new filter technologies, revealing the factors that are important at the beginning of filter use, i.e. the uptake of a new behavior, is of particular interest. A clearer understanding of these determinants enables behavioral-change interventions to be planned to promote filter use and consumption of fluoride- treated water.

Determinants of behavior change

Various prominent models of behavior change provide a multitude of constructs to identify the key determinants of health behaviors. This study focuses on several content-related key determinants of health behavior without following a specific theory. Various constructs are included that are assumed to play an important role. The focus lies on five different beliefs: risk beliefs, attitudinal beliefs, normative beliefs, ability beliefs, and maintenance beliefs. The description of the five beliefs and their determinants can be found in Table 1.

Table 4: [Table 1 of Study 1] Description of beliefs and their determinants for behavior change

Beliefs	Determinants	Description	Literature
Risk beliefs	Perceived vulnerability	Perceived probability of the occurrence of a disease.	e.g. Becker et al. (1977), Maddux and Rogers (1983);
	Perceived severity	Perceived severity of a disease.	
	Health knowledge	Knowledge about the disease (symptoms, how to contract it, how to prevent it).	e.g. Bandura (2004);
Attitudinal beliefs	Time and effort	Time and effort of new behavior (e.g. use of the filter).	e.g. Ajzen (1991), Heri and Mosler (2008);
	Taste	Taste of filtered water.	
	Affect	How much do people like filtered water, how pleasant/unpleasant and how healthy/unhealthy do they find filtered water.	
	Costs	Costs of treated water (perceived costs of filter media).	

Normative beliefs	Descriptive norm	What is typical or "normal", i.e. what do most people do.	e.g. Ajzen (1991), Cialdini et al. (1990), Mosler et al. (2010), Schwartz (1977), Conner & Armitage (1998);
	Subjective norm	What do important others think about the behavior.	
	Personal norm	Personal feelings or moral obligations.	
	Status norm	How proud/ashamed people feel having a filter and being able to provide others with filtered water.	
Ability beliefs	Perceived behavioral control	People's perception of the ease or difficulty of performing a specific behavior (filtering water).	e.g. Ajzen (1991), Bandura (2004);
	Self-efficacy	People's judgment of their capability to manage performing activities and to the effort they will expend toward a specific activity (filtering water).	
Maintenance beliefs	Commitment	Perceived commitment towards the behavior (using the filter).	e.g. Prochaska and DiClemente (1982), Orbell et al. (2001), Verplanken & Aarts (1999), Tobias (2009), Heckhausen (1991);
	Perceived habit	Perceiving the performance of the behavior as a habit (filtering).	
	Automaticity	Automaticity of performing the behavior (filtering).	
	Remembering	Remembering to perform the behavior (filtering).	

The main purpose of the present field study is to test the social and psychological determinants of the consumption of fluoride-free water to assess valuable implications for specific intervention contents. The results of this survey shall identify enhancing and hindering factors of filter use and further provide knowledge about how to successfully implement new filter technologies and how to persuade people to sustainably use the technologies.

Methods

To evaluate possible determinants to increase the consumption of fluoride-free water, a cross-sectional survey was employed. After a pilot project in 2007, in April 2010, the project was continued with the distribution of 200 fluoride removal household filters. The filter design consists of a two-bucket system, with a smaller (10 L) bucket on top containing 2 L of sand for turbidity removal and a lower bucket (30 L) containing bone

char and calcium phosphate pellets as filter media for fluoride removal. One filling of 8 L of water can be filtered within half an hour. The sand in the upper bucket needs to be washed from time to time. Depending on the fluoride content of the raw water and the frequency of filter use, the filter media must be exchanged after approximately 1 year to ensure defluoridation effectiveness. The total filter cost is approximately 38 US dollars ($14 for the media, $24 for the hardware). Before the distribution, people were informed that they will have to pay 10% of the initial price and agree to pay 50% for the filter media when the filter needs refilling. Also prior to the distribution, the local NGO tried to find out together with the village leaders and the community facilitators, how many households are interested in purchasing a filter. In the end, four villages were selected to benefit from the 200 filters. For the distribution of the filters, villagers gathered around the market place to collect their filter buckets and fill them with the bone char. Before receiving the filters, the NGO's social worker and the research assistant gave information about fluoride and fluorosis, as well as clarifying how to operate and maintain the filter.

Study areas

The filters were distributed in four different villages, Seriti (approximately 200 households), Gura, Chalaleki 1, and Chalaleki 2 (with approximately 100 households each) close to Lake Ziway. The project areas were selected by the local NGO Oromia Self Help Organization (OSHO) and the research team based on fluoride concentration levels, accessibility, and the permission of regional leaders. All of the project areas, rural villages with low-income families, are located in the northern part of the Ethiopian Rift Valley. The villagers, mostly self-sustaining farmers, live basically in little houses built of wood, earth, tin, cement, or concrete and their infrastructure is quite simple (no electricity, sanitation, or fluent water). Usually, people fetch water at a public water source such as a borehole. The fluoride content of the water sources in the project are have been measured at 2–18 mg/L. These fluoride levels partially exceed the World Health Organization (WHO) guideline value of 1.5 mg/L (Tekle-Haimanot et al. 2006).

Sample and procedures

The study design was a complete survey of all filter beneficiaries in the project areas (200 households). Filter users who received a filter in April 2010 were interviewed approximately 2 weeks after distribution of the filter. In this baseline survey, all filter users

consented to being interviewed. Because of inclement weather, 40 households in one remote village (Seriti) were not accessible and therefore could not be interviewed.

Because of high illiteracy, the data collection was carried out through structured face-to-face interviews by a team of 10 local college students. Before the survey, the interviewer team attended a workshop learning all about fluoride, fluorosis, and defluoridation, and interviewing techniques (e.g. how to approach a household, how to avoid asking suggestive questions, how to deal with negative reactions). During the investigation, the team was supervised by researchers and field assistants. If possible, the interviews were held with persons responsible for drinking water in the respective household.

Questionnaire and measures

The structured questionnaire was translated by the local field manager and social worker from English into two local languages (Amharic and Oromic) and revised by the interviewers during the workshop. The applicability of the questionnaire was verified in a pretest (20 households). During the pretest the research team examined the interviewers in order to validate important measures (e.g. estimation of content of jerrycans or cups). The questionnaire was designed to cover various factors of interest underlying the filter use and the consumption of filtered water, including mainly quantitative variables. In general, the quantitative bipolar variables were measured on a 9- point Likert-scale; for the unipolar variables, a 5-point Likert-scale was used. After data collection, principal factor analysis with varimax rotation and reliability analysis— Cronbach's alpha (α)—were executed with SPSS 17.

Consumption of fluoride-free water The dependent variable for the current consumption of filtered water was quantified in terms of the percentage of drinking filtered water and cooking with filtered water. Participants were asked to show the interviewer a regular cup and to assess how many of these cups the entire family drank per day and used for cooking per day. With the interviewer's estimation of the content of the cup, the total liters consumed per day could be calculated. Afterwards, people were asked how many cups of filtered water the participants used for consumption. The percentage of filtered water consumption compared to total consumption was calculated. From this calculation, two consumption types were extracted: households that consume only filtered water (100% of filtered water consumption) and households that still consume untreated water in addition to filtered water (less than 100% filtered water consumption).

Table 5: [Table 2 of Study 1] Items used for calculation

Scale/construct	Example items	Lowest value	Highest value
Vulnerability	How high or low do you feel are the chances that someone of your family develops skeletal fluorosis? The chances are...	-2 = much lower than average	2 = much higher than average
Severity	Imagine that you contracted dental/skeletal fluorosis, how severe would be the impact on your life in general?	0 = not severe at all	4 = very severe
Health knowledge	How can you prevent getting fluorosis?	4 multiple choice answers, for each:	
	a) With boiling the water before consuming it.	0 = answer was wrong	
	b) With filtering the water before consuming it.	1 = answer was right	
	c) With taking medicine.		
	d) With brushing your teeth more often.		
Time and effort	Do you think using the filter is effortful?	0 = not effortful at all	4 = very effortful
Taste	How much do you like or dislike the taste of filtered water?	-4 = I dislike it very much	4 = I like it very much
Affect	How much do you like or dislike consuming filtered water?	-4 = I dislike it very much	4 = I like it very much
Costs	What to you think about the price of 120 Birr[1] for a refill of the filter media?	-4 = much too cheap	4 = much too expensive
Descriptive norm	How many of your neighbors you know who have a F-removal filter?	0 = (almost nobody)	4 = (almost) all
Subjective norm	Most of my neighbors think I should use the filter.	-4 = I strongly disagree	4 = I strongly agree
Personal norm	I feel a strong personal obligation to consume filtered water.	-4 = I strongly disagree	4 = I strongly agree
Status norm	How proud or ashamed are you to offer filtered water to your guests?	-2 = very ashamed	2 = very proud
PBC (filter capacity)	How often do you need more water for drinking and cooking than is available from the filter?	0 = (almost) always	4 = (almost) never
Self-efficacy	How confident are you that you will be able to use the filter regularly in the next month?	0 = not confident at all	4 = very confident
Commitment	Do you feel committed to use the filter?	0 = not committed at all	4 = very much committed
Perceived habit	How much do you feel that you fill the filter as a matter of habit? Filling the filter is...	0 = not at all a habit	5 = a very strong habit
Automaticity	I fill the filter automatically without thinking much about it.	-4 = I strongly disagree	4 = I strongly agree
Remembering	How difficult is it to remember filling the filter with water?	0 = very difficult	4 = not difficult at all

[1] 1 Ethiopian Birr = 6 US cents (exchange rate on the 13.6.2011).

Behavior determinants The questionnaire included items concerning risk beliefs, which was covered by the perceived vulnerability and perceived severity of dental and skeletal fluorosis (e.g., Orbell et al. 2009). Moreover, health knowledge about fluoride and fluorosis was measured with Kprim styled multiple-choice questions (Krebs 2002), a method used if several elements influence an issue. To each aforementioned question (one example is illustrated in Table 2), four responses were developed based on open responses from the pilot survey. For each response, the participants had to decide whether it was correct or not. For four correct ratings of one question, participants received one point; for three correct ratings half a point. Finally, the points were tallied up. Krebs (2002) justifies the scoring system (zero points if more than one answer is wrong) by pointing out that different elements of one question should be known in order to have knowledge about an issue.

Furthermore, questions regarding attitudinal beliefs such as time and effort, and perceived taste were elevated, as well as affective beliefs about health and whether or not the activity itself is agreeable (cf. Table 2). The descriptive norm was covered following Smith et al. (2008), the subjective norm following Park and Smith (2007) and Armitage (2005), and the personal norm is according to Harland et al. (2007). Perceived behavior control was assessed in terms of having enough filtered water available for consumption (see Table 2). Self-efficacy was measured in reference to Armitage (2005). Maintenance belief items were defined as shown in Table 2 (e.g., Orbell et al. 2001).

Results

In 78.8% of the cases, the interviewed person was female. According to the participant's preference, the interviews were conducted in Amharic (20.6%) or Oromic (79.4%). The majority of participants were Ethiopian Orthodox (95%). The average age of the respondents was 33.1 years (SD = 10.6, N = 149). On average, the interviewees had attended school for 1.5years (SD = 2.2, n = 159; 61.6% of the participants did not go to school at all). The mean number of people living in one household was six people (range: 1–16 people).

Out of the total sample (N=160), 79.6% of the filter users stated they drank and cooked exclusively with filtered water. Of those who still consumed certain amounts of raw water, only 6.9% indicated they exclusively drank unfiltered water, while 21.9% stated they cooked with raw water. The filter was filled on average 2.65 times per day (SD = 1.25), mostly when it was completely empty (43.1%). The means and standard

deviations of the observed variables regarding filter use and determinants of filter use are shown in Table 3.

Table 6: [Table 3 of Study 1] Means, standard deviations of dependent and independent variables, and Cronbach's alpha for scales

	Variable	*n*	*Range*	*M*	*SD*	α
Behavior	Consumption type*	160		Binary variable		---
Risk beliefs	Vulnerability	160	-2 to 2	-0.21	1.23	.93
	Severity	160	0 to 4	3.62	0.45	.80
	Health knowledge	158	0 to 5	2.96	1.18	
Attitudinal beliefs	Time and effort	160	0 to 4	2.84	1.17	.56
	Taste	160	-4 to 4	3.66	0.69	---
	Affective belief	160	-4 to 4	3.97	0.28	.76
	Costs	160	-4 to 4	0.43	2.29	---
Normative beliefs	Descriptive norm	160	0 to 4	1.60	0.75	.74
	Subjective norm	160	-4 to 4	3.26	0.89	.84
	Personal norm	160	-4 to 4	3.73	0.37	.71
	Status norm	159	-2 to 2	1.40	1.13	---
Ability beliefs	PBC (filter capacity)	159	0 to 4	2.84	1.40	---
	Self-efficacy	160	0 to 4	3.69	0.40	.76
Maintenance beliefs	Commitment	160	0 to 4	3.72	0.52	.79
	Perceived habit	160	0 to 5	3.53	0.55	---
	Automaticity	160	-4 to 4	1.91	2.93	---
	Remembering	160	0 to 4	3.71	0.84	---

Note. No attempt was made to reconstruct missing data. Theoretical range is displayed. For factors with multiple items, Cronbach's alpha (α) for scale reliability is indicated.

*Consumption type (1 = only consuming filtered water, 0 = still consuming raw water).

The mean, in reference to perceived vulnerability, indicates that filter users estimated their likelihood of contracting fluorosis as neither low nor high. Means regarding the perceived severity of dental and skeletal fluorosis (see Table 3) indicate that the impact of dental and skeletal fluorosis was considered severe up to very severe. Regarding health knowledge, the means show that filter owners have a moderate knowledge of fluoride and fluorosis.

The high values of the attitudinal beliefs such as time and effort, taste, and affective belief, indicate that in general people evaluate the filter and filtered water as very positive. As shown in Table 3, the costs for a refill of the filter media is on average considered valid.

On average, filtering the water was not perceived as time-consuming or requiring much effort.

The descriptive norm shows a moderate mean. The values concerning the subjective and personal norms (compare Table 3) indicate that the perceived expectations of the social network regarding filter use was considered high, and in general, significant others approved the use of the filter. Furthermore, filter users were proud to offer filtered water to guests.

The filter capacity with a mean of 2.81 and a relatively high standard deviation (see Table 3) indicates that there are users who perceived themselves as not being able to produce enough filtered water for the whole family, though users in general saw themselves as being capable of using the filter regularly (compare Table 3).

People seemed to feel deeply committed to using the filter. Furthermore, they perceived the filling of the filter as a good habit and they easily remembered to use the filter. Automaticity reached a mean of 1.91, indicating that the beneficiaries did not quite automatically fill the filter. However, the relatively high standard deviation reflects that this is not the case for all users (see Table 3).

To evaluate the main factors that predict fluoride-free water consumption, a binary logistic regression was carried out (see Table 4). The enter method was used to include all hypothesized behavior determinants. Because the dependent variable is dichotomous, a logistic regression was used as the method. The regression results show which factors determined the consumption of only filtered water or the consumption of additional untreated water.

Outlier analysis showed the necessity of excluding four cases (all cases with residuals exceeding more than 3 SDs) from the regression sample, resulting in a total sample size of 156. These outliers were not due to data-entry error and, therefore, could potentially bias the results. The self-efficacy factor showed, after preliminary calculation, a high variance inflation factor (VIF) value, which indicates collinearity with other predictors in the regression (Fox and Monette 1992). A correlation analysis revealed a high correlation between self- efficacy and perceived habit ($r = .54$). Thus, self-efficacy was excluded from the final regression analysis.

Table 7: [Table 4 of Study 1] Logistic regression analysis for variables predicting consumption of filtered water

	Variable	*B*	*SE B*	Exp (*B*)	*p*	*CI (95%) for Exp (B)*
Risk beliefs	Vulnerability	.134	.269	1.143	.618	[.675, 1.936]
	Severity	-.125	.948	.882	.895	[.138, 5.652]
	Health knowledge	-.382	.334	.683	.254	[.354, 1.315]
Attitudinal beliefs	Time and effort	.156	.286	1.169	.586	[.668, 2.045]
	Taste	**1.155**	**.467**	**3.174**	**.013**	**[1.271, 7.926]**
	Affect	-.212	1.034	.809	.838	[.107, 6.135]
	Costs	**.332**	**.150**	**.717**	**.026**	**[.535, .962]**
Normative beliefs	Descriptive norm	-.037	.478	.963	.938	[.378, 2.456]
	Subjective norm	-.568	.455	.567	.212	[.232, 1.382]
	Status norm	**2.222**	**.518**	**9.228**	**.000**	**[3.341, 25.491]**
Ability beliefs	**PBC (filter capacity)**	**1.205**	**.319**	**3.336**	**.000**	**[1.787, 6.229]**
Maintenance beliefs	Commitment	.455	.509	1.577	.371	[.582, 4.273]
	Perceived habit	**1.912**	**.650**	**6.766**	**.003**	**[1.893, 24.183]**
	Automaticity	-.093	.125	.911	.456	[.713, 1.164]
	Remembering	-.167	.411	.846	.684	[.378, 1.893]
Constant		-14.06	4.641	.000	.002	

Note. Nagelkerke R^2 = .679, LR-χ^2 = 91.446 with *df* = 15 (p < .000), *n* = 156 (due to outlier removal); a forced entry method was used for the calculation.

Five variables contributed significantly in predicting the probability of consuming only filtered water. A positive perceived taste of filtered water increased the likelihood of drinking and cooking 100% with water from the filter. The perceived costs of filter material influenced consumption of only treated water. The more people perceive filter media as expensive, the more often the probability that they exclusively consume filtered water. Moreover, the probability of consuming only filtered water was significantly higher if filter owners were proud of offering treated water to their guests, as shown by the positive impact of status norm in the regression (compare Table 4). A positive perceived behavior control and perceived habit of using the filter increased the chance of consuming filtered water. None of the risk belief factors showed significant influence in the regression.

In total, there was a good model fit (Nagelkerke= 67.9%), and 88.8% of the consumption types were correctly classified. The calculated VIF values showed no evidence of high multicollinearity; thus, all values are between 1.12 and 1.68. Furthermore,

standardized residuals were normally distributed in both regressions. In addition, homoscedasticity in the calculated regression was ensured.

Discussion

The purpose of the present research was to reveal substantial social psychological determinants of consuming fluoride-free water deriving from relevant factors of various behavior change theories. One goal was to gain knowledge about how using the filter and filtered water is perceived, what people's risk beliefs were, and how users estimate social impacts. It was of particular interest to identify factors that influence users who consume only filtered water in order to derive interventions to decrease the number of raw water consumers.

In general, filter owners consume a respective amount of treated water within their daily requirement. This applies to drinking filtered water as well as to cooking with filtered water. The fact that filter users paid a contribution for the filter and obtained the filter only a short time before the survey was conducted may offer an explanation for this finding.

Even though all villages have access only to highly contaminated water, people do not feel vulnerable to dental or skeletal fluorosis. Also, the hypothesized impact of risk beliefs on the probability of consuming filtered water could not be confirmed. However, Gerrard et al. (1996) pointed out that estimating the likelihood of contracting a certain disease seems to depend on various socio-demographical and situational factors. Moreover, in the project area, deep tube wells and boreholes for fetching groundwater were installed only around 10 years ago. Before that, mainly surface water was consumed, which had lower fluoride concentration than groundwater. This circumstance implies that the older generation of villagers was not exposed to dental fluorosis during their childhood and therefore might feel less vulnerable to skeletal fluorosis.

Attitudinal beliefs toward filtering were in general very positive. The perceived cost of filter media is the only attitudinal belief, which is neither high nor low, but on average is perceived as valid. This is not surprising taking into account that the average monthly income in the rural area is low. Further, it was expected that filter users were influenced by attitudinal beliefs. The better tasting the treated water is perceived to be, the more probable the likelihood is that filtered water will be consumed exclusively. Before filter distribution, people expressed their concerns about bone char media changing the taste of treated water. Learning that their assumptions were unverified probably surprised the participants and led to a highly positive taste perception. Interestingly, the costs

variable operated in an inverse relationship than what had been expected. The significant effect indicates that the more expensive the filter material is perceived to be, the more likely households will consume filtered water exclusively. In other words, the more the filter material is evaluated as expensive, the more valuable they might become and the more likely filter users will consume only filtered water. This finding is consistent with Cialdini's (2001) assumed stereotype of "expensive products must be good," which works as a judgmental heuristic. The positive role of price was also examined by marketing researchers such as Lichtenstein et al. (1993), who stated that the high price of a product can be perceived as positive because the consumer relates the high price to higher quality.

Overall, normative beliefs were positive. Neighbors, friends, and significant others seemed mostly to approve of filter usage, probably because of the health effect. However, neither descriptive nor subjective norms showed significant influence on behavior. Not finding a positive influence is reasonable, taking into account that using a household filter is a private rather than public displayed behavior. Filter owners feel proud to present their treated water to guests. In addition, the perceived personal obligation is mainly high among users. Having purchased something valuable and now possessing an expensive new device might be drivers for feeling proud and obligated to use the filter. The status norm, the feeling of pride in offering filtered water to guests, showed the strongest positive impact. Thus, the more people feel proud offering filtered water to guests, the more probable that they will consume only filtered water. This finding can be explained by the importance of visiting in the Ethiopian culture. Being able to serve healthy water to neighbors and friends visiting seems to be meaningful and thus influences filter use.

Furthermore, filter users perceive themselves as capable of using the filter regularly even though many users believed the filter bucket was too small to produce enough water for their whole family. Perceived behavior control showed a strong positive influence on filter use. The positive impact indicates that the more users feel they have enough water available, the more likely that they will consume exclusively filtered water. The behavior itself, filling the filter and consuming filtered water, seems not to be considered difficult. By contrast, producing enough filtered water for the whole family, which means filling the filter at the right moments when filtered water is needed, requires more effort.

Finally, maintenance beliefs show that people feel very committed to using their filter, and perceive filling the filter as a matter of habit, even though the automaticity of filling could increase. Remembering to fill the filter was perceived as easy. Considering that the action of filling is easy to perform and that the big colorful filter bucket on its own

acts as a reminder, these results are not unexpected. The perceived habit of filling the filter seems to be a strong predictor of the probability of filter use. The more the filter refilling is perceived as a habit, the more likely that new users will consume only filtered water. Findings of recent research on use of solar water disinfection (SODIS) showed that habit is an important variable for explaining the increase of SODIS use (Kraemer and Mosler 2010). However, filtering the water is a relatively easy activity to perform, and people may quickly develop a perceived habit if they fill the filter once a day (e.g., every morning). Therefore, the influence of perceived habit on new users' filter use does not indicate that users fill the filter sufficiently per day to cover their total water consumption. Probably, filling the filter more than once may become more difficult in the daily routine and is more coherent with perceived automaticity of filling the filter.

Limitation of the study and future research

Some limitations of the present study are noteworthy. One limitation is the self-reported data and the interviewers' questions that may evoke a social bias. During the workshop, the interviewers were sensitized to that problem and the importance of the introduction before starting the interview. In the introduction, the interviewers pointed out that participants should answer in their interest as honestly as possible. However, another type of survey such as a paper-and-pencil investigation would have been impossible due to the high illiteracy rate in the population, and observed behavior monitoring would have been very difficult and highly reactive.

Additionally, the behavior measurement itself needs improvement. It seems appropriate in future research to focus on how much water is filtered per day as the dependent variable, because it is assumed that water, which was filtered is also consumed sooner or later. With this variable, linear instead of logistic regressions could be calculated with the advantage that the results will be more conclusive and more meaningful to interpret. However, various studies about health behavior implementing self-reported data indicate its significance for behavior performance (e.g., Holm et al. 2003; Verplanken and Orbell 2003).

Before discussing the implications for practice gained from these results it has to be mentioned that the following findings might have been different for other Ethiopian populations in other areas. Therefore, a follow-up study in different areas would be advisable.

Implications for practice

Bone char filtration seems to be widely accepted among the household filter users, even though most of them know that the filter material is a processed animal product. Hence, a defluoridation technique was found that is simple, effective, inexpensive, and socially accepted by the Ethiopian population.

Regarding the implementation of household filters, the advantage of bigger buckets with more storage capacity should be considered due to the result that the probability of consuming only filtered water increases if people feel that there is enough water available from the filter. Furthermore, it is favorable to set a contribution price for new filters as well as for the filter material, which is perceived as costly and therefore considered as something valuable. Further, inconsistent filter filling should be a focus. New users should be induced to fill the filter more than once or twice a day, depending on the number of family members, by giving them rules of thumb (e.g., filling the filter once per day per person in household). A positive perceived taste of treated water is an important factor enhancing filter use. Therefore, before new filter technologies are implemented, filter media should be tested regarding taste. Fortunately, bone char material does not seem to change the taste of raw water; moreover, after filtering, the water seems very tasty. The fact of an overall positive perceived taste can be used for promotion within the community for gaining new filter users.

Intervention strategies to maintain or improve filter use should target perceived habit of filtering. Prompts or a daily routine planning together with promoters could be effective intervention strategies for forming a habit in terms of an automatic behavior performance of filling the filter to have as much water as needed for the entire household. Prompts are external memory aids that act as situational cue stimuli and lead to habit formation (Dahlstrand and Biel 1997). Effective tools for daily routine planning are, for example, implementation intentions, which help people perform a specific behavior by making concrete plans of actions that specify how, where, and when actions should be performed to achieve an intended goal (Gollwitzer 1999). When the filter should be filled and how to incorporate the consump- tion of filtered water in daily routines should be discussed with the filter users.

To further enhance treated water consumption, the status norm should be taken into account. A public commitment intervention could target the importance of presenting filtered water to guests. Individuals communicate in public to perform a certain behavior (Mosler and Tobias 2007). One possibility is to provide filter users with a clear noticeable

sign (e.g., a flag on the rooftop, a poster on the front door). The pride of possessing a filter and being able to provide guests with healthy water is hence visible to the community. Further, the public commitment enhances a descriptive norm for filter use and at the same time evokes a social pressure to do what they communicated in public for themselves. Various studies showed the effectiveness of this intervention technique in changing behavior (e.g., De Young 1993; Dwyer et al. 1993).

This study reveals important insights into the usage of a newly implemented household water treatment system. Intervention strategies to further enhance and develop habitual usage of fluoride removal filters can be developed and implemented to increase safe water consumption and prevent dental and skeletal fluorosis.

Study 2: Stimulating Long-Term Use of Fluoride-Removal Household Filters

Abstract

Two hundred million people worldwide and 8.5 million people in Ethiopia are at risk of developing fluorosis due to the naturally high concentrations of fluoride that exist in ground- and surface water. To prevent fluoride uptake, fluoride-removal household filters were distributed in the northern Ethiopian Rift Valley. The aim of the present study is to determine whether the technical intervention of distributing the filters is sufficient to ensure their sustainable usage, or if additional psychological interventions are necessary to ensure behavior change. A longitudinal survey with three measurement points was conducted. Three intervention groups were evaluated. Group 1 received the filter as the only intervention. Groups 2 and 3 additionally received the following psychological interventions in different order: a planning and social prompt intervention and an educational workshop with pledging. The results show that implementing fluoride-removal filters is not sufficient to ensure sustainable behavior change regarding filter use. The psychological interventions proved to be useful for promoting fluoride-free water consumption: After each of the interventions, behavior (consumption of fluoride free water) increased. Thus, it can be concluded that it is essential to accompany the implementation of a new device with psychological interventions.

Keywords**:** Behavior change, social prompt, pledging, fluoride-removal filter, Ethiopia

Introduction[2]

Approximately 200 million people worldwide rely on drinking water with excessive fluoride concentrations (Amini et al., 2008). Fluorine is a common element that exists in the form of fluoride in a number of minerals and is widely distributed in the earth's crust (World Health Organization [WHO], 2011). Fluoride is absorbed in the human body mainly by drinking and cooking with contaminated water (Tekle-Haimanot et al., 2006). It gets incorporated in teeth and bones where it can develop a toxic effect if is excessively consumed (WHO, 2011). Whilst dental fluorosis is characterized by brown patches on the teeth, the symptoms of skeletal fluorosis are joint pain, limited joint movement, deformation of bones, and in the last state, even crippledness. In addition, affected people encounter numerous psychosocial problems, such as feeling embarrassed when smiling and social exclusion (Tekle-Haimanot, 2005).

Out of a population of 10 million, in the Ethiopian Rift Valley, 85 percent are affected by excessive fluoride, which has caused a serious public health problem (Tekle-Haimanot, 2005). Fluoride concentrations much higher than the 1.5mg/l guideline that has been set by the World Health Organization (WHO, 2011) are found in water sources (Tekle-Haimanot et al., 2006). Since medical treatment is costly, difficult, and mostly ineffective, the prevention of fluoride uptake is essential. People must be given access to fluoride-free water. Filtering is a feasible solution, especially when rainwater harvesting or piped water supplies not possibly. The Nakuru technique, a filtering technique that consists of combining bone char and calcium-phosphate pellets, provides a simple, efficient, and low-cost way of filtering water. The technique is applicable at household and community levels (Korir et al., 2009).

When governmental or non-governmental organizations implement technical interventions and provide people with new health-improving technologies (e.g. fluoride-removal filters), they often just assume that these will be used sufficiently. However, studies examining the use of new technologies for safe drinking water show that this is not the case. New technologies will not be used sufficiently on a long-term basis if no additional interventions are carried out (e.g. Huber et al., 2011; Mosler et al., 2010; Tobias and Berg, 2012). In the case of drinking water, adherence needs to be at least at a level of 80 percent to have a positive effect on health (Brown and Clasen, 2011). The difficulty is

[2] This study is submitted: Sonego, I., Huber, A. C., & Mosler, H.-J. (submitted). Stimulating long-term use of fluoride-removal household filters. *Environmental Science & Technology*.

that people need to switch from an old behavior (e.g. using a contaminated raw water source) to a new behavior (e.g. using the new technology). In order to perform a behavior change, people need to undergo a psychological change as well.

The risk, attitude, norms, abilities, self-regulation (RANAS) model proposed by Mosler (2012) conceptually describes influential factors of health behavior changes. As the name implies, the RANAS model (Mosler, 2012) groups the behavioral determinants into five different blocks: risk factors, attitude factors, norm factors, ability factors, and self-regulation factors. All of these factors influence the uptake and maintenance of a new healthy behavior. The RANAS model also contains corresponding psychological intervention techniques for each factor block. In order to know which factors to target, a baseline survey should be carried out about the desired behavior as well as all psychological factors. To evaluate the success of an intervention, the behavior change as well as the targeted factor should be assessed in a second survey. The present study evaluated a technical intervention (provision with a household filter) and psychological interventions based on pre-intervention data.

Immediately following the acquisition of a new device, commitment and use are typically high, especially if a financial contribution was made (Cialdini, 2007). Consistent with this assumption, Emery and Blumenthal (1990) found that elderly adults' adherence to an exercise program was extremely high during the first 16 weeks. But after six months, there was a 50 percent dropout rate. Therefore, although there was a short-term behavior change, it was not sustainable. We hypothesize that people who receive a fluoride removal filter as a technical intervention will be committed at first, and therefore change their behavior, but with time this commitment will decrease and the behavior change will not be sustained.

Results from a baseline survey (see Huber et al., 2011) suggested that increasing people's perceived habits would enhance the filling of the household filter and increase fluoride-free water consumption. Therefore, a planning and prompt intervention was applied in the first intervention phase.

First, within the planning phase, an individual plan of when to fill the filter in the course of the day was worked out since planning is supposed to influence perceived habits (Mosler, 2011). A prompt or memory aid is a written, signed, or spoken cue that urges a person to act in a defined situation (Tamas and Mosler, 2011). There is considerable research evidence that prompts are capable of inducing behavior change such as recycling behavior (Holland, 2006) or using the stairs instead of the escalator (Soler et al., 2010).

Prompts are assumed to have a positive influence on self-regulation factors, most of all on remembering to perform the target behavior (Tobias, 2009). In the present study, a new concept was used: a social prompt. In contrast to traditional prompts (e.g. stickers, posters), a social prompt involves an additional person ideally from the close social environment of the target person. In the best case scenario, the two people are living in the same household. The "social prompt person" is instructed to help the other person to remember a certain behavior. For example, Gras and colleagues (2003) found that a single spoken prompt influences seat belt use, whereas Ohtomo and Ohnuma (2010) found effects of a spoken prompt on pro-environmental behavior. Our hypothesis is that the planning and social prompt intervention will induce behavior change by augmenting perceived habits and remembering.

The baseline survey conducted by Huber and her colleagues (2011) further revealed filter users' moderate level of knowledge concerning fluoride and its prevention, but they also found that status norm (what individuals present to their neighbors) influenced filter usage. Therefore, the second intervention in the present study was an educational workshop followed by a pledging. The workshop, according to Mosler (2012), is classified as a persuasive intervention. Pledging is defined as
"the pledging or binding by oneself, as in committing oneself to a course of action" (Kiesler, 1971, p. 26). The fact that people generally want to be seen as consistent makes pledging, especially public pledging, a successful intervention (Cialdini, 2007). It is assumed that pledging publicly leads to a higher level of personal commitment. De Young (1993) stated in his review that the most noteworthy aspect of commitment techniques is their capability to induce sustainable behavior change. Furthermore, Rogers (2003) asserted in his *Diffusion of Innovations Model* that communication is an important determinant of whether or not a person will change a certain behavior. So far, various studies have confirmed the essential rule of communication in health behavior change (e.g. Bingham et al., 2011; Rimal et al., 1999). Communication was found to be a predictor in the adoption of family planning strategies in Tanzania (Vaughan and Rogers, 2000) and for condom use in African American females (Sales et al., 2012). Therefore, it is assumed that communication is positively influenced through the public gathering that ensues during an educational workshop. Hence, we hypothesize that an educational workshop that includes pledging will lead to behavior change by augmenting commitment and communication.

The present study

The aim of the present study is to determine whether psychological interventions are necessary or if technical interventions are sufficient to ensure sustainable behavior change in daily water usage. Behavior change is considered sustainable when at least 80 percent of the daily water requirement consists of with fluoride-free water, which is the level required to have a beneficial effect on health (Brown and Clasen, 2011). Therefore, the effectiveness of one technical intervention and two psychological interventions on specific psychological factors and on behavior change were analyzed. A longitudinal study consisting of three surveys over the course of one year was carried out in several rural villages in the Northern Rift Valley, Ethiopia. The two psychological interventions were chosen and designed according to Mosler's RANAS model for behavior change (Mosler, 2012).

The first was a technical intervention in which people could acquire the fluoride-removal filter by paying a significant portion of their generally low income, which covered about 10 percent of the actual cost of the filter. This intervention and, in particular, paying the contribution, is considered to raise people's commitment towards filter use.

The psychological interventions were chosen after analyzing the baseline survey (results published by Huber et al., 2011). Based on the baseline results, two psychological interventions were applied: 1) the planning and social prompt targeting perceived habits and remembering, and 2) the educational workshop with pledging, targeting commitment and communication.

Three groups were investigated and surveyed longitudinally at three measuring times. All three groups received a fluoride-removal household filter. Group 1 received the filters shortly before the start of the study, but received no further interventions afterwards. In this group, the effect of the mere technical intervention, the acquisition of the filter is investigated. Groups 2 and 3 also received psychological interventions in addition to the technical intervention. In order not to confound the effects of the new acquisition of the filter with the effects of the psychological interventions, beneficiaries who had already owned the filter for three years prior to the study were chosen. After the baseline survey, Group 2 received the planning and social prompt intervention and three months later attended the educational workshop. At first, Group 3 received no intervention, but later, members of this group also attended the educational workshop. The dependent variable of the present study is the consumption of fluoride-free water.

Summarizing, the hypotheses of the present study are:

- H1a) Group 1 receiving the fluoride-removal filter as a technical intervention will increase their consumption of fluoride free water in the beginning, but it will then decline.
- H1b) Group 1 will increase commitment initially, but then it will decline over time.
- H2a) Group 2 receiving the planning and social prompt intervention will increase their consumption of fluoride free water, and with the educational workshop with pledging afterwards, they will further increase their consumption of fluoride-free water.
- H2b) Group 2 will experience increases in perceived habits and remembering after the planning and social prompt intervention as well as increases in commitment and communication after the educational workshop with pledging.
- H3a) Group 3 receiving no intervention will at first reduce their consumption of fluoride-free water, but after attending the educational workshop with pledging they will increase their consumption of fluoride-free water.
- H3b) Group 3 will lower their commitment at first and then increase in terms of both commitment and communication after attending the educational workshop with pledging.
- H4) A new device alone as a technical intervention is less effective in terms of instituting sustainable behavior changes in the consumption of fluoride-free water than with a psychological intervention.

Methods

Research area

The study was conducted in the northern part of the Ethiopian Rift Valley in two different rural villages (Weyo Gabriel and Chalaleki 2) close to Lake Ziway. The project area was chosen together with the local non-governmental organization (NGO), the Oromia Self Help Organization. Permission from regional leaders was obtained. The project's beneficiaries are low-income families, mostly self-sustainable farmers who live in simple clay huts without electricity, fluent water, or proper sanitation facilities. The local languages are Amharic and Oromic. Even though there is an elementary school, the educational level in both villages is very low, and most adults are illiterate. With exception of the rainy season when rainwater can be harvested, people usually fetch water either at public water selling points, such as windmills or electric pump boreholes, or from private

hand dug wells or the nearby lake. Those different water sources exceed the recommended WHO guideline of 1.5 mg of fluoride per liter by far, since measured concentrations are between 2mg/l and 18mg/l (Tekle-Haimanot et al., 2006).

The village of Weyo Gabriel was part of a pilot project where fluoride-removal household filters could be acquired with the financial support of the Oromia Self Help Organization in May 2007. In April 2010, the project continued with the distribution of more fluoride-removal household filters in the village Chalaleki 2. Huber and colleagues (2011) conducted a baseline study in May 2010. Since it was impossible to begin interventions during the rainy season in the summer, a second baseline (T1) was conducted in September 2010. Follow-up surveys were conducted in February 2011 (T2) and in May 2011 (T3).

Procedure and interventions

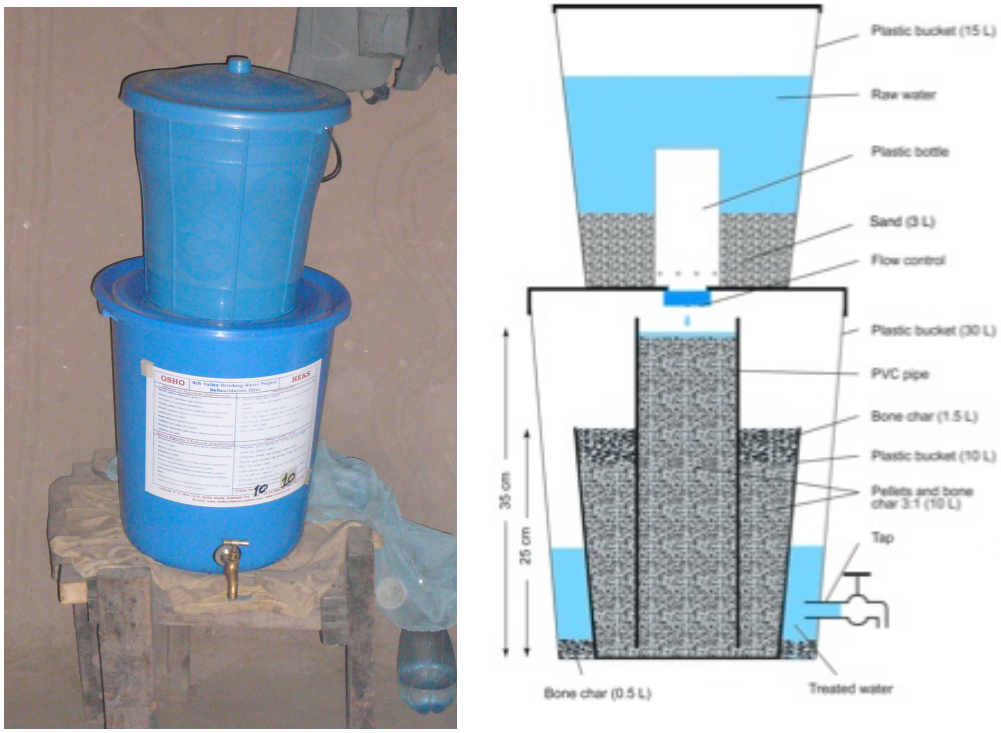

Figure 14 [Figure 1 of Study 2]. Fluoride removal household filter in the main house of a rural family in the Ethiopian Rift Valley. (Images by Lars Osterwalder, Eawag).

The fluoride-removal household filter was designed by the Catholic Diocese of Nakuru and the Oromia Self Help Organization. It contains of a two-bucket system (see fig. 1). The upper bucket contains three liters of locally available sand for turbidity removal. The upper bucket is filled with raw water, which flows into the lower bucket through a flow control. The PVC tubes in the lower bucket are filled with 1.5 liters of bone-char and 10 liters of calcium phosphate pellets for defluoridation. After running

through the filter media, the water is collected in the storage bucket and can be retrieved by the tap. The storage capacity is approximately 20 liters. The lifespan of the filter material is from three months up to one year, depending on the intensity of use and the fluoride concentration in the raw water. The price of one filter is 48 US dollars (including the filter first filter media batch), of which beneficiaries agreed to pay ten percent. The filter owners also agreed to pay half of the price of the filter media replacement after saturation. One refill costs about 14 US. Users where instructed to wash the sand in the upper bucket once a week, but not to open the lower bucket.

A longitudinal study was conducted to determine intervention effects on household filter use and fluoride-free water consumption. Three groups were compared over time. Group 1, which had recently obtained the fluoride-removal filter as a new device, did not receive any additional interventions. For Group 1 all the beneficiaries from the village Chalaleki 2 were sampled. In order to avoid confounding the effects of the psychological interventions with the effect of the newly achieved device, Groups 2 and 3 were sampled from the pilot project where inhabitants of the village Weyo Gabriel had received fluoride-removal filters three years ago. During those three years, no interventions were carried out. The beneficiaries were randomly assigned to Group 2 or Group 3. Group 2 first received a planning and social prompt intervention and later attended an educational workshop that included pledging. Unlike Group 2, Group 3 did not receive an intervention initially, but they also attended the workshop. Even though for the design of the study it would have been preferable to hold the workshop only for Group 2, Group 3 was invited for participation too because holding a public meeting and only inviting half of the village could have led to tensions.

Villagers interested in acquiring a filter could contact Oromia Self Help Organization. A distribution day was held where all the villagers who wanted a filter gathered at the village health center. Husbands and wives were invited to come. The NGOs social worker provided information about fluoride and the filter. In order to ensure that beneficiaries gained sufficient knowledge about the characteristics of the filter, it was decided that each couple should build its own filter under the supervision of the NGO team. They had to fill sand in the upper bucket, mix the filter media and fill it in the lower bucket, and then put the filter together. Then, they were instructed on how to handle it properly. Additionally, they received information on fluorosis and its prevention.

Planning and social prompt

Beneficiaries of the village Weyo Gabriel belonging to Group 2 received a visit from a promoter in January 2011 lasting approximately half an hour. When possible the promoters talked to the person in the household responsible for water. In most cases, that person was the mother. Using a "personal filter filling sheet" (Fig. S1) they calculated the total daily water consumption for drinking and cooking in liters. Then, they calculated how many times a day the filter should be filled in order to obtain the needed amount of water. Knowing this number, the planning was done with the help of a colorful circle that included the typical daily events of a rural family (Fig. S2). The suitable and convenient times to fill the fluoride removal filter were found and marked on the circle. Subsequently, the responsible person in each family committed herself to always filling the filter at those moments, and sealed the commitment with a handshake. In order to obtain the social prompt, an additional person, usually a child or another member of the household got involved. The circle and the filling moments were explained to this person, who then committed to always helping the responsible family member to remember when to fill the filter.

Educational workshop with pledging

The educational workshop with pledging was conducted for members of Groups 2 and 3 in the beginning of April 2011. Only women were invited to the workshops. They were informed three days in advance by the field coordinator. They were also informed that there would be an allowance of 30 Ethiopian Birr, which is as much as a worker's average daily income. Paying an allowance for the attendance of workshops or meetings is common and required in Ethiopia and was therefore highly recommended. The workshop's duration was approximately three hours. A well-known and influential woman from the village itself was appointed to be the workshop leader. She was assisted by the NGOs social worker and supervised by the field assistant and the research team. The workshop contained a persuasive informational session on fluoride, its effects on health, and prevention. Then, there was an interactive group game to repeat and deepen participants' knowledge. At the end of the workshop during the pledging, all women raised their hands indicating that they wanted to pledge. Then, they anal stood up and pledged to only use filtered water for drinking and cooking. For more details on this educational workshop, see Supporting Information on page S2f.

Sample

Of the interviewees, 81 percent were females. Huber and colleagues (2011), who conducted the first baseline survey, reported a very low educational level for participants. On average, they had attended school for 1.5 years and about 60% of the participants had not gone to school at all. They found an average household size of six people (ranging from one to 16). The majority's religion was Ethiopian Orthodox (95%). Further, they reported an average age of 33.1 years (SD = 10.6).

Data gathering and questionnaire

Due to the high illiteracy rate amongst the beneficiaries, the surveys were carried out in a structured face-to-face interview format. An interviewer team of eight local college students, who had already worked with the research team before, was recruited. They were retrained for two days, before each of the surveys, to discuss and practice the questionnaire. The training was held by the research team with the assistance of the NGOs social worker and a field assistant. During all the surveys, the interviewers were accompanied to the field and supervised. The questionnaires were translated by the social worker and the field assistant from English into Amharic and Oromic. They were subsequently revised by the interviewers during the training and pre-tested in the field. The beneficiaries' households were visited without preannouncement. The interviewees were informed that participation was voluntary. They received information on the study and verbal informed consent was given. The interviews were conducted with the person responsible for water in the household. The duration of the interview was approximately one hour.

The questionnaires were designed to measure filter use, fluoride-free water consumption, and the underlying psychological factors. In the post-intervention questionnaires (T2 and T3), sections with questions about the previous intervention were included. These questions were used to analyze beneficiaries' subjective opinions on the previous promotion activities.

Dependent variable: fluoride-free water consumption

In the present study the dependent variable is the consumption of fluoride-free water in liters per day and per person in a given household. First, participants were asked how many times a day the filter was filled. Second, the number of liters filtered per day and per household was calculated. Since some beneficiaries reported using other sources of fluoride-free water (they would use rainwater, or buy water from a reverse osmosis plant or

at a community filter), in a third step, the amount of water (in liters) obtained from these sources was added as well. Finally, the amount of fluoride-free water consumed per day and per household was divided by the number of people living in each household, resulting in the dependent variable: the consumption of fluoride-free water in liters per day and per person in a given household. This measure for consumption of fluoride-free water was used for calculations. Behavior change can be quantified as the variations in consumption over time. However, the measure of consumption of fluoride free water per day and per person can only be interpreted by comparing it to the total consumption of water in liters. Therefore, the total consumption of water was also assessed. Participants were asked to show cups used for drinking and cooking and assess how many of those cups would be used in a day. With the interviewer's estimation of the cups' size, the total amount of water used for drinking and cooking can be calculated. By dividing this number by the number of people living in a household, a measure for total (raw and fluoride-free) water consumption per day and per person in each household was obtained.

Psychological factors

Four psychological factors were used for analysis. Perceived habit was operationalized with three items: "I fill the filter automatically without thinking much about it," and "Filling the filter with water is something I do without consciously remembering." The answers were given on nine-point Likert scales (-4 = I strongly disagree, 4 = I strongly agree). The last item for perceived habit was "How much do you feel that you fill the filter as a matter of habit?" The answer was given on a five-point Likert scale (0 = not at all a habit, 4 = a very strong habit). For analysis, the last item was later matched to the nine-point Likert scale as well. Remembering was operationalized by the question: "How often do you forget to fill the filter with water?" The answer was given on a five-point scale (0 = (almost) always, 4 = (almost) never). Communication was operationalized by the question: "How often do you talk about the filter or fluoride-free water?" The answer was given on a six-point scale (0 = never, 6 = every 1 to 3 days). For commitment, three items were used. The first item was: "How important is it for you to fill the filter regularly?" The answer was given on a five-point Likert scale (0 = not at all important, 4 = very important). The second item was: "How annoyed do you feel if you forget to fill the filter?" The answer was given on a five-point Likert scale (0 = not at all annoyed, 4 = very annoyed). The third and final item for commitment was: "Do you feel committed to use the filter?" The answer was given on a five-point scale (0 = not at all committed, 4 = very committed).

Data analysis

To test hypotheses H1a to H3b, Wilcoxon's sign ranked tests were used to compare means of consumption of fluoride-free water within groups over time and to compare means of psychological factors within groups over time. To test hypothesis H4, Mann-Whitney U tests were used to compare means of consumption of fluoride-free water between groups at T1 as well as at T3. According to H4, groups should not differ at T1. At T3, Group 1 should be inferior to Groups 2 and 3, whereas Groups 2 and 3 should not differ from one another. Non-parametric tests were chosen instead of t-tests because the required assumption of normal distribution in the psychological factors as well as in the dependent variable was not met. Additionally, effect sizes calculated according to Rosenthal (1991) are reported. Effects >.1 are considered small, effects >.3 as medium, and effects >.5 are considered large (Cohen, 1988).

Results

The mean of the total water consumption per day and per person over all three panels (T1, T2, and T3) is 4.55 liters (SD = 2.63, N = 75). This represents the required amount of water per day and per person for drinking and cooking and would therefore be the optimum amount for the consumption of fluoride-free water per day and per person.

The mean of the consumption of fluoride-free water of all groups increases over the three panels from 2.55 liters (SD =1.66) at T1 to 3.29 liters (SD = 2.29) at T2 and 3.26 liters (SD = 1.82) at T3, respectively. The quite high standard deviation should be noted. All households reported using the filter, and most seem to consume a mixed amount of filtered and unfiltered water. The percentage of households who consume at least 4.55 liters per day and per person increased from 9.9 % at T1 to 18.7% at T2 and remained 18.7% at T3.

Change over time for Group 1

Table 1 displays the results of the Wilcoxon signed rank test for Group 1. H1a stated that Group 1 should increase their target behavior (consumption of fluoride-free water) from T1 to T2 and decrease from T2 to T3. Group 1 increased in terms of their consumption of fluoride-free water from 2.63 liters at T1 to 3.89 liters at T2, with a medium effect, $p = .001$, $r = .38$. From T2 to T3, there was a decline to 2.69 liters, with a medium effect, $p = .002$, $r = .37$. Thus, H1a can be accepted. H1b stated that Group 1 should increase in commitment from T1 to T2 and decrease from T2 to T3. Commitment

did not change significantly from 3.63 at T1 to 3.71 at T2, $p = .16$, $r = .13$; further, there was a non-significant change to 3.63 at T3, $p = .12$, $r = .15$. Therefore, H1b cannot be accepted.

Table 8 [Table 1 of Study 2]. Results of Wilcoxon Signed Rank Test Statistics for Group 1

		T1	T2	T3	Wilcoxon Signed Rank Test Statistics							
H	**Factor**	**M**	**M**	**M**	**Δ T1T2**				**Δ T2T3**			
		(SD)	***(SD)***	***(SD)***	**Δ**	**Z**	**p[a]**	**r[b]**	**Δ**	**Z**	**p[a]**	**r[b]**
1a	Behavior	2.63 *(2.1)*	3.89 *(3.0)*	2.69 *(1.4)*	1.26	-3.23	.001	.38	-1.2	-2.82	.002	.37
1b	Commitment	3.63 *(.5)*	3.71 *(.4)*	3.63 *(.4)*	.08	-.99	.16	.13	-.08	-1.16	.12	.15

Note. Hypothesis *(H)*, means *(M)*, and standard deviations *(SD)* are provided.
[a] significance of p is one-tailed; [b] effect size (Rosenthal 1991, p. 19).

Change over time for Group 2

Table 9 [Table 2 of Study 2]. Results of Wilcoxon Signed Rank Test Statistics

		T1	T2	T3	Wilcoxon Signed Rank Test Statistics							
H	**Factor**	**M**	**M**	**M**	**Δ T1T2**				**Δ T2T3**			
		(SD)	***(SD)***	***(SD)***	**Δ**	**Z**	**p[a]**	**r[b]**	**Δ[b]**	**Z**	**p[a]**	**r[b]**
2a	Behavior	2.29 *(.93)*	3.22 *(1.5)*	3.52 *(2.1)*	.93	-1.93	.027	.27	.30	-.74	.23	.10
2b	Perceived habit	2.30 *(2.0)*	2.14 *(1.9)*	--	-.16	-.47	.32	.19	--	--	--	--
2b	Remembering	3.60 *(1.3)*	3.12 *(2.1)*	--	-.40	-1.02	.15	.14	--	--	--	--
2b	Communication	-- --	2.50 *(2.1)*	3.38 *(1.9)*	--	--	--	--	.88	-1.98	.029	.26
2b	Commitment	-- --	3.44 *(.80)*	3.69 *(.30)*	--	--	--	--	.26	-.89	.18	.12

Note: Hypothesis *(H)*, means *(M)*, and standard deviations *(SD)* are provided.
[a] significance of p is one-tailed; [b] effect size (Rosenthal 1991, p. 19).

Table 2 displays the results of the Wilcoxon signed rank test for Group 2. H2a stated that Group 2 should increase their target behavior from T1 to T2 and again from T2 to T3. Group 2 increased in terms of their consumption of fluoride-free water from 2.29 liters at T1 to 3.22 liters at T2, with a medium effect, $p = .027$, $r = .27$. After that there was non-significant change to 3.52 liters at T3, $p = .23$, $r = .10$. Thus, only the part of H2a that refers to the change from T1 to T2 can be accepted. H2b stated that Group 2's perceived habits and remembering should increase from T1 to T2 and that their commitment and communication should increase from T2 to T3. Perceived habits changed non-significantly from 2.30 at T1 to 2.14 at T2, $p = .32$, $r = .19$. Remembering did not change significantly from 3.60 at T1 to 3.12 at T2, $p = .15$, $r = .14$. Communication increased from 2.5 at T2 to 3.38, with a medium effect, $p = .029$, $r = .26$. Commitment did not change significantly from 3.44 at T2 to 3.69 at T3, $p = .18$, $r = .12$. H2b can thus only partially be accepted. The part of H2b referring to changes from T1 to T2 needs to be rejected. However, for changes from T2 to T3, results are mixed. Commitment did not change as hypothesized, whereas communication did.

Change over time for Group 3

Table 10 [Table 3 of Study 2]. Results of Wilcoxon Signed Rank Test Statistics for Group 3

		T1	**T2**	**T3**	**Wilcoxon Signed Rank Test Statistics**							
H	**Factor**	***M***	***M***	***M***	**Δ T1T2**				**Δ T2T3**			
		(SD)	***(SD)***	***(SD)***	**Δ**	**Z**	**p[a]**	**r[b]**	**Δ**	**Z**	**p[a]**	**r[b]**
3a	Behavior	2.83	2.30	3.96	-.53	-.53	.30	.14	1.66	-.19	.028	.51
		(1.7)	*(1.5)*	*(1.8)*								
3b	Commitment	3.91	3.80	3.71	-.11	-.92	.18	.17	-.09	-.66	.25	.12
		(.3)	*(.4)*	*(.3)*								
3b	Communication	--	2.75	3.56	--	--	--	--	.81	-1.25	.10	.22
		--	*(2.5)*	*(1.9)*								

Note: Hypothesis *(H)*, means *(M)*, and standard deviations *(SD)* are provided.
[a] significance of p is one-tailed; [b] effect size (Rosenthal 1991, p. 19).

Table 3 displays the results of the Wilcoxon signed rank test for Group 3. H3a stated that Group 3 should decline the target behavior from T1 to T2 and increase their behavior from T2 to T3. Group 3 decreased non-significantly in their consumption of

fluoride-free water from 2.83 liters at T1 to 2.30 liters at T2, $p = .30$, $r = .14$. Subsequently, behavior increased to 3.96 liter at T3, with a strong effect, $p = .028$, $r = .51$. Thus, only the part of H3a that refers to a change from T2 to T3 can be accepted. H3b stated that Group 3 should reduce their commitment from T1 to T2 and increase in terms of both commitment and communication from T2 to T3. Commitment changed non-significantly from 3.91 at T1 to 3.80 at T2, $p = .18$, $r = .17$. It again changed non-significantly to 3.71 at T3, $p = .25$, $r = .12$. Communication increased marginally from 2.75 at T2 to 3.56 at T3, with a small to medium effect, $p = .10$, $r = .22$. Thus, H3a cannot be accepted, with the exception of the part referring to communication.

Differences between groups

Group 1 (M = 2.63, SD = 2.1) and Group 2 (M = 2.29, SD = .93) did not differ in terms of their fluoride-free water consumption at T1, $U = 362.5$, $p = .68$ (two-tailed), $r = .06$. However, at T3 Group 1 (M = 2.69, SD = 1.4) consumed less water by trend than Group 2 (M = 3.52, SD = 2.1), $U = 291.5$, $p = .076$ (one-tailed), $r = .19$. Groups 1 and 3 (M = 2.83, SD = 1.7) did not differ at T1, $U = 196.5$, $p = .40$ (two-tailed), $r = .12$. But at T3, Group 1 consumed less water than Group 3 (M = 3.96, SD = 1.8), $U = 121$, $p = .016$ (one-tailed), $r = .32$. In addition, Groups 2 and 3 did not differ at T1, $U = 162.5$, $p = .49$ (two-tailed), $r = .11$, or at T3, $U = 151$, $p = .19$ (two-tailed), $r = .14$. Therefore, H4 can be accepted.

Discussion

The aim of the present study was to determine the effectiveness of our interventions on behavior change regarding consumption of filtered water and on underlying psychological factors. Of special interest was the question of whether psychological interventions have an additional effect on ensuring sustainable behavior change after the fluoride-removal filters are distributed, or if the distribution itself as a technical intervention is sufficient.

In the complete sample, the consumption of fluoride-free water increased from T1 to T3. Whereas only about 10 percent of the beneficiaries filtered enough water to cover their total water consumption at T1, by T2 and T3 this number had increased to about 20 percent. The other beneficiaries consumed a mixed amount of filtered and unfiltered water.

It was predicted by H1a that Group 1, who received the new device as a technical intervention, would have an initial increase in the target behavior, but then decline in the

long term. The results supported this hypothesis. At T3, one year after the distribution of the fluoride-removal filter, the behavior in Group 1 was as low as at the baseline, namely at 2.29 liters. Considering that the average person uses 4.5 liters of water per day for drinking and cooking, this is a rather dissatisfying result. Only slightly more than 50 percent of the total amount of consumed water is covered by fluoride-free water. Since fluoride concentrations in the research area included in this study are well above the 1.5mg/l level recommended by the World Health Organization (Tekle-Haimanot et al., 2006), the beneficiaries who receive no psychological interventions are still at high risk of contracting fluorosis in spite of owning a fluoride-removal filter. To ensure long-term behavior change, it is not sufficient to provide people with a new device without promoting it. The low values for fluoride-free water consumption in Group 2 and Group 3 at T1 strengthen this statement. After three years of owning the fluoride-removal filter those two groups had a similarly low level of consumption of fluoride-free water as Group 1 at T3. This observed decline in a new healthy behavior after initiation is consistent with other research. As noted earlier, a 50 percent dropout rate was found in an exercise study (Wallace et al., 2000). Other short-lived changes in healthy behavior are dietary changes (Kumaniyka et al., 2000) and adherence to medication (Cramer, 2004).

H1b included our expectation that commitment in Group 1 would increase from T1 to T2 and then decline to from T2 to T3 in the long term. In contradiction to the hypothesis, commitment did not change over time but was very high at all three measurement times. Ceiling effects probably made change immeasurable. Presumably, other psychological factors apart from commitment play a role as well, and all psychological factors of the five factors blocks of the RANAS model (Mosler, 2012) should be taken into account for analysis.

According to H2a, the target behavior of Group 2 should have increased from T1 to T2 and then again to from T2 to T3. Between T1 and T2, Group 2 received the planning and social prompt intervention. As expected, behavior increased. The planning and social prompt intervention seems to be an effective way to increase the target behavior of fluoride free water consumption. This is consistent with other findings that indicate the effectiveness of prompts (e.g. Austin et al., 1998; Gras et al., 2003). However, contrary to the hypothesis, there was no further increase in behavior after participants' involvement in the educational workshop that included a pledging component. At T3, about 80 percent of the total water consumption of Group 2 was covered by filtered water. There might be a limit to the number of people who can be reached by an intervention that aims at learning

and performing a new healthy behavior as well as to the extent to which people are willing or able to perform it. It is possible that Group 2 already approached or reached this limit after the first psychological intervention, the planning and social prompt, so that another increase after the second psychological intervention, the educational workshop with pledging was not possible. Consistent with this finding, even 50 years after the invention of the seat belt and despite laws and intensive campaigning, seat belt use remains below 90 percent in front seats and even below 70 percent in back seats in Europe (European Transport Safety Council, 2009).

According to H2b, the perceived habits and ability to remember to use the filter should have increased for Group 2 from T1 to T2, as well as their commitment and communication from T2 to T3. Surprisingly and in contradiction to the hypothesis, perceived habit and remembering did not increase. We assume that because of the planning and social prompt intervention, both habits and remembering are perceived differently. There could be two reasons for this. The first is that before the intervention, beneficiaries probably did not have a specific goal regarding the number of times a day to fill the filter and especially not regarding specific times in the day to fill it. After the intervention, most of them wanted to fill it about three times a day and at very specific moments. So before the intervention, an irregular routine would not have been perceived as forgetting or having an irregular habit, but after the intervention it was. So it seems plausible that even if beneficiaries do fill the filter more often after the planning and social prompt intervention, they do not report more remembering or improved habits of filling it because the goal became higher and more specific. The second reason is closely related to the special nature of our prompt, the social prompt, compared to traditional prompts. By being reminded by a prompt that is a person and not an item, one could perceive the reminding as having forgotten to fill the filter or as having poor/irregular habits filling it. So even if the planning and social prompt intervention was capable of increasing behavior, it seems plausible that neither perceived habit nor remembering increased.

As predicted by H2b, communication increased, which means beneficiaries talked more about fluoride and the filter after the intervention. Commitment was high after the workshop as well; however, there was no increase since it was high before the educational workshop.

According to H3a, Group 3 was expected have a decline in the target behavior from T1 to T2 and an increase from T2 to T3 after having attended the educational workshop. Although less fluoride-free water was consumed at T2 than at T1, this change was not

significant. Group 3 had already owned the filter for three years. Even if a steady decline over time is presumed, this decline might be too small and slow to be measurable in such a small group. However, after having attended the workshop, there was an increase in the target behavior. The beneficiaries consumed almost 4 liters of fluoride-free water per day and per person and thus about 85 percent of their consumption was accounted for by filtered water. The results indicate that an educational workshop in which participants pledge to make a change is an effective way of promoting behavior change. Correspondingly, public commitment has also been found to be a motivator for weight loss (Nyer and Dellande, 2010).

H3b involved the assumption that Group 3's commitment would decline from T1 to T2, but then increase along with communication from T2 to T3. Similarly to the results of Group 1, commitment was very high in all three panels. Thus, it neither declined at first nor increased after the workshop. Communication increased marginally after the workshop, as predicted by hypothesis H3b.

According to H4, the sole distribution of the fluoride-removal filter as a technical intervention would be inferior to the addition of psychological interventions in terms of their impact on sustainable use. At the baseline panel T1, there were no differences between groups. As we predicted, at T3, Group 1, receiving only the technical intervention, consumed less fluoride-free water than both Groups 2 and 3. Groups 2 and 3 did not differ in their means. The results show that adding psychological interventions was more effective than implementing the technical intervention alone.

Limitations of the study

Some limitations of the present study are noteworthy. One applies to the size of the sample, which was rather small. There could have been more significant results with larger samples. However, there was no access to a larger sample, because the number of filters distributed by the NGO was limited. Since this is the first project distributing fluoride-removal filters in Ethiopia, it seemed important to gain knowledge for further up-scaling. Another limitation applies to the missing control groups. For Groups 2 and 3, control groups were unrealizable. Whilst it was possible to conduct the social prompt intervention with only a portion of the households in the village (Group 2), the educational workshop had to be offered to the whole village (Group 2 and Group 3). The crucial difference between these two promotions was that the planning and social prompt intervention was a promoter's visit to the households, whereas the educational workshop was a public

gathering. Excluding households of a village from such a public gathering could have caused conflict and was therefore considered unethical. Thus, the workshop had to be available to Group 2 as well as Group 3. Furthermore, the self-reported data and the face-to-face interview situation should be mentioned. Due to the high illiteracy rates, it was impossible to conduct paper-pencil questionnaires. Interviewers were sensitized to the problem of social bias. To reduce social bias in the dependent variable, the consumption of filtered water, we chose to ask about how many times a day the filter was filled instead of asking for a self-estimation of the beneficiaries' consumption of filtered water. In addition, this number should also be much easier to report and therefore more reliable, especially in the case of mixed (filtered and unfiltered) water consumption. Regarding the long-term sustainability of the psychological interventions, it would be advisable to conduct studies examining the effects of psychological interventions after some time has passed (e.g. after six months).

Implications for practice and conclusion

The findings of this study indicate that it is not sufficient to merely implement a new health-improving device, but that it is also essential to accompany the implementation with psychological interventions in order to have a positive effect on beneficiaries' health. This is the only way to ensure that the new device will be used sustainably (see also Cairncross and Short, 2004; Tobias and Berg, 2011). One, respectively three years after the acquisition of the fluoride-removal filter, the consumption of fluoride-free water dropped to around 50 percent, leaving people at high risk of contracting dental or skeletal fluorosis. The present study gives two examples of successful psychological interventions that can promote behavior change: the planning and social prompt intervention and the educational workshop with the pledging. These interventions were capable of increasing consumption from under 50 percent to over 80 percent, thus reaching a level where performed behavior had a positive impact on health. When up-scaling the fluoride-removal filters, NGOs can now use those interventions to promote behavior change. The social prompt was a new kind of prompt. The advantage of a social prompt compared to a traditional prompt is that there are no material costs involved. Since NGOs often have a small budget, this can be essential when up-scaling such promotions. However, it must be kept in mind that psychological interventions should not just be carried out blindly. It is important to choose evidence-based interventions that fit the target group. In a baseline survey, underlying

psychological factors of a new healthy behavior should be assessed, and interventions should be chosen accordingly.

Study 3: Evidence-based Tailoring of Behavior Change Campaigns: Increasing Fluoride-free Water Consumption in Rural Ethiopia with Persuasion

Abstract

Worldwide, 200 million people are at risk of developing dental and skeletal fluorosis resulting from excessive fluoride uptake through water. Since medical treatment of the disease is difficult and mostly ineffective, preventing fluoride intake is crucial. In the Ethiopian Rift Valley, a fluoride-removal community filter was installed. Despite having access to a fluoride filter, the community used the filter sparingly. During a baseline, 173 face-to-face interviews were conducted to identify psychological factors that influence the fluoride-free water consumption. Based on the results, two behavior change campaigns were implemented: a traditional education intervention targeting perceived vulnerability and a evidence-based persuasion intervention regarding perceived costs. The interventions were tailored to the households' characteristics. The campaigns were evaluated with a survey and analyzed in terms of their effectiveness in changing behavior and the targeted psychological factors. While the intervention targeting perceived vulnerability showed no desirable effects, cost persuasion decreased the perceived costs and increased the consumption of fluoride-free water. This shows that changing the subjective perceptions can change behavior even without changing objective circumstances. Moreover, interventions are more effective if they are based on evidence and tailored to the households.

Keywords: Fluoride-removal filter, behavior change campaigns, perceived vulnerability, perceived costs, intervention, persuasion, tailored interventions, Ethiopia

Introduction[3]

Worldwide, around 200 million people rely on drinking water contaminated with excess fluoride. In Ethiopia, 8.5 million people are at risk of developing fluorosis resulting from excessive fluoride uptake through water. Fluoride is a naturally occurring mineral that at elevated levels becomes a geogenic contaminant of groundwater. Fluoride occurs at high levels in the East African Rift Valley (Tekle-Haimanot et al., 2006). Dissolved in water, fluoride develops a toxic effect on the human body through precipitating the calcium needed, mainly for bone formation (McDonagh et al., 2000). As a result, people who are exposed to high fluoride concentration in water and have an excessive fluoride intake develop dental and skeletal fluorosis. Irregular brown patches on teeth, deformation of bones, limitation of joint movements, and even crippling in the last stage of the disease are symptoms of fluorosis. People suffering from dental and skeletal fluorosis face psychosocial impacts, such as social exclusion and discrimination (Tekle-Haimanot et al., 2006). Because there is no effective medical treatment of the disease, preventing fluoride intake becomes crucial.

To prevent fluoride uptake, people have to stop consuming as much fluoride-contaminated water as possible. However, just making fluoride-free water available—for example, by installing a community filter—is not enough. Many people will not consume sufficient filtered water, since this water might be more expensive, have a different taste, or is farther away, or simply because they follow the old habit of using water from a contaminated source (see, e.g., Tobias & Berg, 2011, for the use of arsenic-removing sand filters). Therefore, technical solutions need to be accompanied by behavior change campaigns that change beliefs about the new water source.

Changing health behaviors with behavior change campaigns

In various health campaigns, persuasive communication has been used to increase desired behaviors (e.g., Albarracín et al., 2003). Persuasive interventions can change different instrumental beliefs, such as perceived benefits or costs. It would stand to reason that, to promote health behavior, persuasion should target health issues. In fact, in development assistance, educational interventions targeting health issues are a common

[3] This study is in revision: Huber, A. C., Tobias, R. & Mosler, H.-J. (in revision). Evidence-based tailoring of behavior change campaigns: increasing fluoride-free water consumption in rural Ethiopia with persuasion. Applied Psychology: Health and Wellbeing.

approach. Examples regarding mitigating geogenic contaminations of drinking water comprise mass-media campaigns (e.g., Caldwell et al., 2006) or public education programs (e.g., Hanchett et al., 2002). In spite of their popularity, however, these campaigns had only very limited impacts on changing the targeted health behavior.

In the light of these reports, planning interventions based on health-related messages should be viewed critically. Every health behavior involves different aspects, and persuading people to use a new technology requires identifying influential factors of the targeted behavior. In our opinion, systematically planning interventions based on data is essential. This implies that all psychological factors that potentially influence the new behavior have to be investigated.

For this investigation, we drew on Mosler's (2012) RANAS Model (risk, attitudes, norms, abilities, and self-regulation) because, in contrast to the other approaches, it is consistently derived from theories of social and health psychology such as the Theory of Planned Behavior (Fishbein & Ajzen, 2010) and the Health Action Process Approach (Schwarzer, 2008). These theories have been shown to be successful in explaining and changing all sorts of health behaviors (for the Theory of Planned Behavior, see Ajzen et al., 2007; for the Health Action Process Approach, see Schwarzer, 2008). The RANAS Model (Mosler, 2012) integrates aspects of several theories conceptually to have the whole set of factors determining behavior regarding water, sanitation, and hygiene.

In the proposed model, psychological factors are ordered in five different factor blocks: risk factors, attitude factors, norm factors, ability factors, and self-regulation factors. These factor blocks comprise all factors necessary to explain behavior change (see Albarracín et al., 2005). In the following, the factor blocks of the RANAS Model (Mosler, 2012) are briefly described.

Risk factors (health risk awareness factors) are divided into perceived vulnerability, a person's subjective perception of his or her risk of contracting a disease, and perceived severity, a person's perception of the seriousness of the consequences of contracting a disease (Floyd et al., 2000). Additionally, a person should have an understanding (factual knowledge) about how she or he could be affected by a disease through environmental conditions (Albarracín et al., 2005).

Attitudinal factors include instrumental beliefs and affective beliefs. Instrumental beliefs (outcome expectancies) include beliefs about costs in terms of money, time, and effort; and benefits in terms of savings, or other advantages of the new behavior. Attitudes with affective components (Trafimow & Sheeran, 1998) are feelings arising when

performing or thinking about the behavior. This study surveys the overall instrumental and affective beliefs, but considers three particularly relevant outcome expectancies separately: the perceived health impact of the behavior, the perceived costs of fluoride-free water, and the perceived taste of filtered water.

Normative factors consider the descriptive norm (perceptions of which behaviors are typically performed), the injunctive norm (perceptions of which behaviors are typically approved or disapproved by important others), and the personal norm (personal opinion about what one should do; Cialdini et al., 2006; Schwartz, 1977). As a specific characteristic of the Ethiopian culture, the guest norm has to be taken into account, meaning that the household may be proud of serving fluoride-free water to visiting guests.

The ability factors are represented by a person's confidence in her or his ability to perform a behavior (perceived behavioral control; Fishbein & Ajzen, 2010). Additionally, self-efficacy is the belief in one's capabilities to organize and execute the course of actions required to manage prospective situations (Bandura, 1997).

Finally, self-regulation factors come into play when a behavior is actually performed and maintained over time (Schwarzer, 2008). To perform a behavior continuously, the person has to be committed to doing so, and the behavior needs to be remembered at critical moments (Tobias, 2009). For a behavior to be consistently performed, it has to become habitual and automatic (Orbell et al., 2001).

All factors of the model, except perceived costs and forgetting, are hypothesized to relate positively to the targeted health behavior.

Based on the data gathered on these psychological factors, the most promising factors for a behavior change campaign can be determined. However, in most cases, campaigns target a wide range of different persons or households, and it might be difficult to find one intervention that fits them all. Various authors have proposed tailoring interventions to the characteristics of the targeted persons or households (e.g., Mosler & Martens, 2008). This means that a number of possible interventions are prepared, and according to the characteristics of the person or household, the best-suited intervention is applied. Various studies showed that tailoring interventions to the target group positively affects changing health behaviors (e.g., Wang et al., 2006). Our argument goes even further: an intervention that does not fit the recipient might have negative effects on behavior. Therefore, tailoring the persuasive messages to the recipients is not only an economic question of efficiency but also a necessity to avoid unwanted effects.

The present study

This study investigates a campaign that promoted consuming water from a community filter implemented in the Ethiopian Rift Valley.

The design of the interventions was done as recommended above (i.e., evidence-based and tailored). Based on the baseline survey data, the most promising technique was determined. Further, households for whom the intervention might not be adequate were excluded. A special aspect of this study is that the effectiveness of the intervention was compared not only to a randomly selected control group without intervention but also to cases that received an inadequate intervention according to our assumptions (i.e., an intervention that is not based on evidence and/or is not adequate for a specific household). This paper presents the design of the campaign based on baseline data and an analysis of the intervention effects.

The study was designed to answer three general research questions. (1) Is it possible to change behavior only by changing subjective perceptions and beliefs even if the objective circumstances remain the same? (2) Does it pay off to design behavior-change campaigns based on evidence and to tailor interventions to the target group or apply an intervention only to a predefined selection of the population? (3) According to our assumptions, there should be no difference between cases that do not receive any intervention, cases that receive an inadequate intervention, and cases for which the intervention applied does not fit. Therefore, we ask the following: Are there differences between these groups regarding changes in the target behavior? These research questions lead to the following hypotheses (H = hypothesis; B = behavior; P = psychological factor; E = evidence based design; F = fits households; C = actual control group; ! = 'not'):

H1: An evidence-based tailored intervention changes the targeted psychological factor and by this the target behavior (H1a: $P_{EF} > C$; H1b: $B_{EF} > C$).

H2: Interventions that do not fit the households' characteristics do not have any effect. The same holds for interventions that are not derived from data but based on common sense (H2a: $B_{E!F} = C$; H2b: $B_{!EF} = C$; H2c: $B_{!E!F} = C$).

H3: An evidence-based intervention has more effect on changing behaviors than a campaign based on health-related messages, which might be the most obvious intervention for mitigating health problems. (H3: $B_{EF} > B_{!EF}$).

H4: An intervention that fits the households' characteristics has more effect on changing behaviors than an intervention that does not fit the characteristics of the households (H4: $B_{EF} > B_{E!F}$).

The first hypothesis refers to Research Question 1, H2 to Research Question 3, and the other two hypotheses to Research Question 2.

The design of the campaign will be presented later. To facilitate understanding, we anticipate the result: The most promising factor to be targeted by a behavior change campaign, according to the baseline data, is perceived costs. As the criterion for the fit of this intervention to the households, the perceived costs in the baseline were used. The intervention should be effective only for households with perceived costs higher than the median of 2 (quite expensive).

A commonsense intervention was selected by our nongovernmental organization (NGO) partners, who suggested a health awareness campaign. Expressed in psychological terms, such a campaign targets the perceived vulnerability of the people. Since the design of this intervention should not be evidence-based (i.e., based on data gathered in the baseline), the criterion for this intervention to be adequate for a household was based on the actual vulnerability and not the perceived. The literature states that children below 5 years of age are at higher risk of contracting fluorosis (e.g., Standing Committee on the Scientific Evaluation of Dietary Reference Intakes, Food, Nutrition Board, Institute of Medicine [SCSEDRI], 1997). Thus, the vulnerability intervention was defined as fitting a household if at least one child under 5 years lived in the household.

To conclude, five groups are distinguished: (1) the control group (CTRL), (2) households with cost persuasion showing high perceived costs (COST_FIT), (3) households with cost persuasion but low perceived cost (COST_MISFIT), (4) households with persuasion on vulnerability and having a child younger than 5 years (VUL_FIT), and (5) households with persuasion on vulnerability and no child under 5 years (VUL_MISFIT).

Method

Study population and sampling

For this project, in a village in the northern Ethiopian Rift Valley a community filter was installed. The project village, Weyo Gabriel, is a typical rural village with low-income families. All local water sources exceed the World Health Organization (WHO) guideline of 1.5 mg/l fluoride concentration (World Health Organization, 2004).

According to village leaders and the regional office, approximately 320 households are counted in the project village, of which 120 own household filters. The exact number

of inhabitants is not known due to a lack of census information and frequent migration. The household filter owners were excluded because they are part of another study (see Huber et al., 2011). During the baseline investigation, 173 houses were found to be inhabited, of which 160 households took part in the post-intervention survey (see Figure 1). No household refused to participate after closely being informed about the study and giving their verbal consent, but some families migrated during the project. The interviews were held with persons responsible for drinking water in the respective household. In 65.9% of the cases, the interviewed person was female. The mean age of respondents was 34.7 years (standard deviation SD = 14.5), and their average number of years of education was 1.9 (SD =2.9). The average number of persons living in a household was 4.5 (SD = 2.1). Of the respondents, 48.8% were housewives, 32.5% worked in agriculture, and 18.7% were engaged in other occupations. The interviewees were Ethiopian Orthodox (84.9%), Muslim (10.8%), or Protestant (4.2%).

All households in the sample were systematically assigned to groups based on their characteristics (i.e., having children at high risk or not, and showing concern about price of filtered water or not) and then randomly allocated to control or intervention groups (see Figure 1). The group that received the health-related messages was set to about the same size as the group that received persuasion on costs, since the NGO was convinced that the former would be effective. However, it was rather probable that interventions that do not fit the households failed. Thus, for efficient use of resources and ethical concerns, these groups were smaller. However, this campaign was followed by two more campaigns promoting the consumption of fluoride-free water and all villagers had the chance of being positively affected by an intervention.

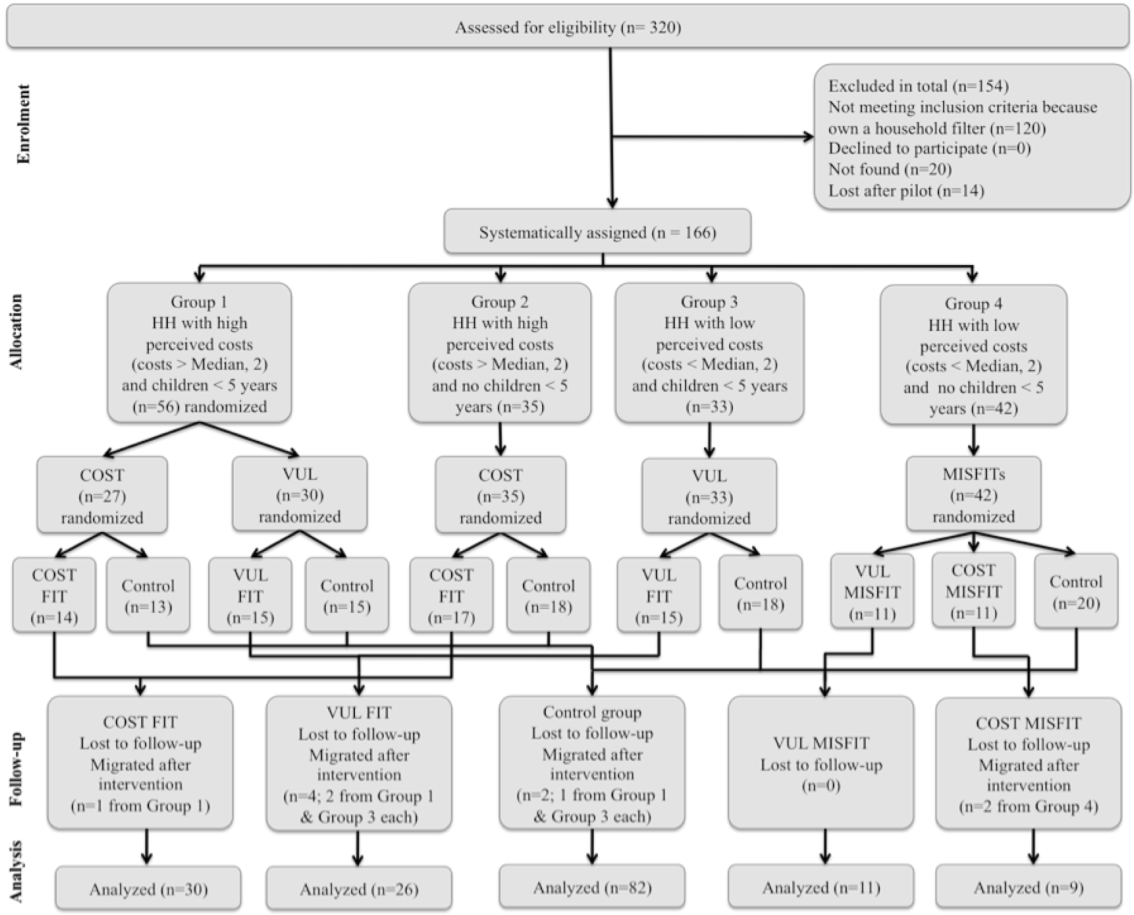

Figure 15 [Figure 1 of Study 3]. Flow diagram of the study design.

Procedure and interventions

The implemented community filter is based on the *Nakuru technique* (Korir et al., 2009), an efficient, simple, and low-cost method that can be applied at the household and community levels. The *Nakuru technique* uses a mixture of bone char (charred animal bones) and calcium-phosphate pellets as filter media (Korir et al., 2009). The community filter is at a central location in the village next to a public raw water source (borehole), where 20 liters of water are purchased for US 1.5 cents. The local water committee, together with the village leaders and NGO members, set the price for treated water at the community filter to US 3 cents per 20 liters. The rather high price was set to ensure a sustainable maintenance of the filter (changing filter material, repairs, caretaker).

The baseline survey took place in September 2010, followed by the intervention phase in October 2010 and a post-intervention survey in December 2010. Before the intervention phase, 10 local health extension workers attended a 3-day training on persuasion techniques and on the content of the promotion. During the intervention phase

in the field, research assistants accompanied the promoters to assure correct household assigning and to make random checks on promoter activities. The following activities took place (further details on the intervention procedure can be found in the Supporting Information Pages S2-S7):

The control group received a short (15 minute) visit from a promoter giving them general information on fluoride, fluorosis, and the community filter (basic knowledge without persuasion attempts).

Households assigned to the cost intervention group received a promoter visit, which lasted approximately 30 minutes. The promoter first provided general information, as in the control group. Additionally, the promoter emphasized the difference in the quality of filtered and raw water. Further, the promoter calculated, together with the head of household, a water budget for that particular household. This way, the household received realistic estimates of how much filtered water was required and how much money the household would have to spend per week.

As in the other groups, households assigned to the vulnerability intervention received a promoter visit, including the general information part. Further, the promoters asked for the names and ages of all children living in the household. Then, the promoter expressed individualized risk information for every child. The promoters showed pictures of children and adults with dental and skeletal fluorosis and indicated, on a visualized water scale, how their risk could be reduced. The visit lasted approximately 30 minutes.

Data gathering and measures

Because of the high illiteracy among the villagers, data collection was carried out through structured face-to-face interviews by a team of 10 local college students. Before each survey, the interviewer team attended a 4-day training course. Moreover, the first author and the research assistants supervised the team during the surveys. The households were visited without preannouncement. It was clearly stated that participation was voluntary, and before the interview began, people were informed about the study and that the results will be treated anonymously and used for research purposes. No visited household rejected the interview. The questionnaires were translated from English into Amharic and Oromic, back translated by two assistants, and finally revised by the interviewers during the workshop. The applicability of the baseline and post-intervention questionnaire was verified in a pretest, and some items were improved. Details of the questionnaire items can be found in the Supporting Information Pages (S8-S10).

Behavior

A behavior index for every household was calculated based on various questionnaire items. First, the person responsible for fetching water reported the weekly purchase of filtered water at the community filter. Second, the interviewee was asked to show the interviewer a regularly used cup and to assess how many of these cups the entire family drinks per day. With the interviewer's estimation of the content of the cup, the total liters consumed per day could be calculated. Afterwards, people were asked how many cups they drank from the filtered water and how many cups they drank from other water sources. The estimation of the percentage of cooking with filtered water followed the same procedure. The percentage of filtered water consumption (drinking and cooking) was calculated compared to the total water consumption.

Perceived costs

People's perceived costs of the community filter water were addressed with one item: "Do you think that 0.5 Birr[1] for one 20 liter jerry can of fluoride-free water is too cheap, too expensive, or right?" Answers were coded on a 9-point Likert-scale (-4 = too cheap to +4 = too expensive).

Data analysis

To determine which psychological factors have the greatest intervention potential, first, the means of all psychological factors were computed. Second, a linear regression of the behavior on these factors was calculated to determine the factors that are significantly related to the consumption of fluoride-free water. For each factor, the sample's mean is subtracted from the factor's targeted value and then multiplied by the regression weight of the determinant B (the slope or strength of association between determinant and behavior). Formally, this can be written as: Intervention potential = (Target – M) * B. The higher the resulting value of the intervention potential for a determinant, the greater the potential impact on behavior for an intervention targeting this determinant.

To test the hypotheses, we cannot follow the common approach for subgroup analyses (e.g., Assmann et al., 2000; Brookes et al., 2004), since we have only one treatment group (COST_FIT) and four groups where we do not expect any effects. A test of interaction over all five groups is not feasible here. First, we are not looking for effects in any group but in one specific group. Second, the effects in this treatment group have to be different from the effects in all four non-treatment groups. Thus, to test the hypotheses,

[1] 1 Ethiopian Birr = 0.059 US Dollars (exchange rate on 3.6.2011)

the differences of effects on all four non-treatment groups must be significant, and therefore, these differences must be tested separately. This multiple testing does not increase the risk of Type I errors. On the contrary, since the four tests are additive, Type I errors are greatly reduced by this design. The only exception is the test of Hypothesis 2. Here it would be possible to do a test of interaction over the four non-treatment groups. However, since we need to test for the *absence* of an effect, an increased Type I error by testing several group differences makes the overall test of the hypothesis even more conservative. Further, single group comparisons would be required if an interaction effect is actually found. Therefore, to test Hypothesis 2, we use single group comparisons.

To test the stated hypotheses, the means of the differences over time were compared with Mann-Whitney U-tests. These within-group changes were calculated as the difference between the post- and pre-intervention behavior (ΔBEH) and perceived costs (ΔCOST). For the differences, the values were scaled from -1 to +1.

To test H1, changes over time of the COST_FIT group are compared to changes in the actual control group (CONTROL). This is done for ΔCOST (testing H1a) and ΔBEH (testing H1b). H2 is tested by comparing ΔBEH of the groups COST_MISFIT, VUL_FIT, and VUL_MISFIT to CONTROL. The test of H3 involves the comparisons of ΔBEH for COST_FIT and VUL_FIT. To test H4, ΔBEH for COST_FIT is compared to COST_MISFIT.

Effect sizes of the mean comparisons have been labeled according to Rosenthal (1991). An effect size r between 0 and $\pm$ 0.3 is interpreted as a weak effect. Effect sizes between $\pm$ 0.3 and $\pm$ 0.4 are considered medium effects, whereas effect sizes between $\pm$ 0.5 and $\pm$ 1.0 are strong effects.

Results

Descriptive statistics and design of the campaign

Descriptive statistics are shown in Table 1. The mean of perceived vulnerability indicates that users estimate their likelihood of contracting fluorosis as lower than the chance of an average person in their community (M = -.351, SD = 2.81). The price of filtered water is, on average, perceived as too expensive (M = 1.62, SD = 2.33). In addition, low values are reported for the descriptive norm, the perceived behavior control, and the automaticity of performing the behavior. All the other factors reached a considerably high mean value (above 2.5).

Table 11 [Table 1 of Study 3]. Descriptive statistics of the factors used in the analyses.

	Factors		*n*	*Range*	*T*	*M*	*SD*	α	*Items*
Baseline T1	Behavior	Percentage of filtered water consumption	173	[0, 100]	100	71.49	32.17	---	
	Risk factors	Vulnerability	173	[-4, 4]	4	-.351	2.81	.921	3
		Severity	173	[0, 4]	4	3.84	.318	.720	6
		Knowledge	170	[0, 5]	5	2.88	1.045	---	
	Attitudinal factors	Overall affective belief	171	[-4, 4]	4	3.49	.791	.882	2
		Overall instrumental belief	173	[-4, 4]	4	3.51	.798	.836	2
		Health impact	172	[-4, 4]	4	3.53	.812	---	
		Taste	173	[-4, 4]	4	2.56	1.48	.831	4
		Perceived costs	173	[-4, 4]	-4	1.62	2.33	---	
	Normative factors	Subjective norm	173	[-4, 4]	4	2.92	1.48	.910	5
		Descriptive norm	173	[0, 4]	4	1.74	0.76	.825	3
		Personal norm	173	[-4, 4]	4	3.01	1.21	.893	3
		Guest norm	172	[0, 4]	4	3.78	0.46	---	
	Ability factors	Perceived behavior control	173	[0, 4]	4	2.05	1.43	---	
		Self-efficacy	173	[-4, 4]	4	2.45	1.64	.883	4
	Self-regulation factors	Commitment	173	[0, 4]	4	3.04	.901	.826	3
		Perceived habit	173	[0, 4]	4	2.96	1.12	---	
		Automaticity	173	[-4, 4]	4	.812	2.89	---	
		Forgetting	173	[0, 4]	0	.690	1.14	---	
Post- intervention T2	Behavior	Percentage of filtered water consumption	172	[0, 100]	100	65.02	33.77	---	
	Risk factor	Vulnerability	172	[-4, 4]	4	-.205	2.31	.872	3
	Attitudinal factor	Perceived costs	172	[-4, 4]	-4	.64	2.62	---	

Note: Targeted values after intervention (*T*), means (*M*), standard deviations (*SD*), and value range (*Range*) of all factors are provided. For factors with multiple items, Cronbach's alpha (α) for scale reliability and the number of items used are indicated. No Cronbach's alpha for knowledge is indicated because of the Kprim-styled multiple-choice measurement (Krebs, 2002).

The results of the regression analysis are presented in Table 2. Perceived vulnerability is negatively related to the consumption of fluoride-free water (B = -3.58); the perceived costs of filtered water (B = - 2.62) and its taste (B = 5.93) also affected people's consumption. In addition, perceived behavioral control (B = 7.04) and commitment (B = 7.41) are significantly related to the consumption of safe water. The

preconditions for performing a linear regression were fulfilled, the residuals were normally distributed, and no evidence of heteroscedasticity or high multicollinearity (VIF values between 1.07 and 1.91) was found.

Table 12 [Table 2 of Study 3]. Linear regression analysis for consumption of fluoride-free water.

Variable		*B*	*SE B*	*β*	*95% CI*		*p*
					LL	*UL*	
Risk factors	Vulnerability	-1.79	.809	-.156	-3.38	-.193	.028
	Severity	-1.98	7.63	-.020	-17.06	13.09	.795
	Knowledge	-.192	2.31	-.006	-4.76	4.38	.934
Attitudinal factors	Overall affective belief	-5.93	6.29	-.146	-18.37	6.51	.348
	Overall instrumental belief	10.18	6.72	.255	-3.10	23.47	.132
	Health impact	.738	4.96	.019	-9.06	10.54	.882
	Taste	5.93	1.83	.276	2.31	9.55	.002
	Perceived costs	-2.62	1.02	.190	.61	4.63	.011
Normative factors	Subjective norm	2.81	2.88	.112	-4.53	10.61	.330
	Descriptive norm	3.04	3.83	.073	-2.88	8.51	.428
	Personal norm	-5.61	3.57	-.215	-12.68	1.45	.119
	Guest norm	4.57	5.04	.065	-5.381	14.53	.365
Ability factors	Perceived behavior control	7.04	1.93	.312	3.223	10.85	.000
	Self-efficacy	-2.17	2.51	-.112	-7.131	2.80	.390
Self-regulation factors	Commitment	7.41	3.67	.210	.161	14.66	.045
	Perceived habit	-2.28	3.54	-.080	-9.28	4.72	.520
	Automaticity	-.082	.871	-.007	-1.80	1.64	.925
	Forgetting	2.34	2.12	.084	-1.88	6.53	.271
Constant		9.64	39.18		-6.78	-.39	.806

Note: B = unstandardized regression coefficient; *SE B* = standard error of *B*; β = standardized coefficient; *CI*= confidence interval; *LL* = lower limit; *UL*= upper limit; *p* = significance level. Adjusted R^2 = .292; *N* = 166. A forced entry method was used for the calculation.

To determine which psychological factors should be targeted by the campaign, the mean values of the factors in Table 1 are subtracted from the target value, and this value is multiplied with the Bs of the regression analysis [(Target – M) * B = Intervention potential]. The highest intervention potential was reached for perceived costs [((-4) – 1.62) * -2.62 = 14.72] and for perceived behavior control [(4 – 2.05) * 7.04 = 13.73]. As

perceived behavior control (the perceived ability to fetch enough water for the whole family) is related to the price of filtered water, we decided to intervene on perceived costs. The behavior change campaign targeting perceived costs was designed not only to lower people's price perception but also to show them that fetching filtered water for only drinking and cooking is not as expensive as expected. The relation between vulnerability and consumption of filtered water is negative. Thus, the 'common sense' intervention obviously is not supported by the data; therefore, we can compare the effects of an evidence-based intervention with an intervention that is not supported by evidence.

Intervention effects

The results of the group comparisons for testing the hypotheses are presented in Table 3. H1 is clearly supported by the effects on perceived costs ($p = .047$) as well as the changes in the behavior ($p = .001$). Remarkably, in the actual control group, a significant decay of the behavior was observed ($p=.009$, $r = .282$). One possible reason for this could be the lack of an intervention, apart from receiving information, so that people fall back into old habits of consuming raw water.

H2 is in principle supported by the data, since none of the groups that received an intervention without effect-expectation showed significant *positive* effects (COST_MISFIT: $p = .590$; VUL_FIT: $p = .560$; VUL_MISFIT: $p = .066$). Since we test for the *absence* of an effect, p-values need to be greater than .25. This is not the case for VUL_MISFIT. Surprisingly, however, this group *reduced* consumption of fluoride-safe water, indicating a negative effect of the intervention.

H3 and H4 are supported by the data: a significantly more positive change was observed for the COST_FIT group than the VUL_FIT group ($p = .037$) and for the COST_FIT group than for the COST_MISFIT group ($p = .004$).

Table 13 [Table 3 of Study 3]. Results of Mann-Whitney U-tests. Comparisons of means of behavior change over time (ΔBEH) of the intervention groups with the control group and with each other and comparisons of means of perceived cost over time (ΔCOST) of the intervention groups with the control group.

Hypotheses tested	Comparison	Compared groups		*M (SD)*	*M (SD)*	*U*	p^a	r^b
		Group A	Group B	*Group A*	*Group B*			
1a	**ΔCOST**	COST_FIT	CTRL	-.267 (.31)	-.101 (.43)	953	.047	.19
1b	**ΔBEH**	COST_FIT	CTRL	.18 (.43)	-.14 (.46)	1782.5	.001	.32
2a		COST_MISFIT	CTRL	-.39 (.41)	-.14 (.46)	419.5	.590	.06
2b		VUL_FIT	CTRL	-.03(.43)	-.14 (.46)	1174.5	.560	.06
2c		VUL_MISFIT	CTRL	-.003 (.41)	-.14 (.46)	304.5	.066	.02
3	**ΔBEH**	COST_FIT	VUL_FIT	.18 (.43)	-.03 (.48)	516.5	.037	.28
4	**ΔBEH**	COST_FIT	COST_MISFIT	.18 (.43)	-.39 (.41)	52	.004	.45

Note: [a] significance of p is two-tailed; [b] effect size (Rosenthal, 1991, p. 19).

Discussion

This study investigated two campaigns for promoting the consumption of fluoride-free water in the Ethiopian Rift Valley. Interventions were derived based on evidence, and target groups were specified for which the interventions should be effective. The effects of these evidence-based and tailored interventions were compared to those of interventions not derived from evidence and that might not fit the households.

Data from the baseline survey suggested that the biggest effect on behavior change should be reached by targeting perceived costs for filtered water and perceived behavior control. Therefore, a behavior change campaign was applied with the goal of influencing perceived costs. However, different NGOs working in developing countries apply educational interventions on health issues (e.g., vulnerability). Although our regression analysis showed a negative relation between perceived vulnerability and target behavior, a behavior change intervention targeting perceived vulnerability was applied. This occurred for two reasons. First, we wanted to integrate the wish of our partner NGO to have a health awareness campaign. Second, we wanted to compare our evidence-based approach with an intervention that seemed to make more sense to practitioners, even if the intervention was not supported by evidence. Following the same logic, even though groups were specified a priori that should be targeted by the campaign, the interventions were applied also to households for which the techniques might not be effective.

The first hypothesis test compared the effects of the evidence-based tailored intervention (COST_FIT) to the control group regarding changes in perceived costs and behavior. H1 was clearly supported by the data, since in this group perceived costs decreased and the consumption of community filter water increased. Thus, the persuasion on perceived costs was able to change people's consumption behavior positively without changing the actual circumstances (e.g., without changing the objective costs of filtered water). The results from the baseline showed that the perceived price played an important role regarding people's consumption behavior. This result is also often found in marketing research (e.g., Monroe, 1973; Lichtenstein et al., 1993). Even though persuasion studies show that instrumental beliefs, such as perceived costs, can be changed (e.g., Petty et al., 2004), few studies show that price perceptions can be changed through persuasion without changing the actual circumstances. We assume that the household's personal water budget contributed significantly to the positive change in price perception. Helping people

calculate their actual weekly expenditure for filtered water might have led to false beliefs about the costs of consuming only filtered water.

The second hypothesis tested whether the interventions not supported by evidence and/or that did not fit the households had effects. No positive effects were found, but in the VUL_MISFIT group, an almost significant *decrease* in fluoride-free water consumption was observed. One reason for this result might be that the intervention failed to change people's perceived vulnerability. Another reason for this might be that the persuasion part focused only on children's vulnerability to contracting fluorosis. Children up to 5 years are actually at the highest risk, but emphasizing this might have caused a negative reaction in adults' behavior. After the promoter visit, people might have concluded that it is important only for their children to consume fluoride-free water. Because untreated water is less expensive, adults might have reverted to consuming more raw water after the intervention. On a more general level, by not designing and tailoring interventions based on evidence, one might not only spend resources on ineffective campaigns but also even might provoke negative effects.

Testing Hypotheses 3 and 4 involved a comparison of the effects of the evidence-based tailored intervention (COST_FIT) to the non-evidence-based intervention (VUL_FIT) and the non-tailored intervention (COST_MISFIT). The results of the study support our hypotheses. The intervention on perceived costs was significantly more effective in changing people's consumption of safe water than the vulnerability intervention. Identifying perceived costs as the factor with the highest intervention potential helped to design an effective intervention. Further, people who received an intervention on costs having high perceived costs at baseline increased consumption of fluoride-free water more than people who did not show high perceived costs. When an intervention is applied to a whole community without being tailored, the intervention might reach households that do not need an intervention or do not meet the requirements for that specific intervention. This can reduce the efficiency of a campaign or even lead to harmful effects, as was shown for the VUL_MISFIT group.

When NGOs design interventions to promote a health behavior, they often apply awareness creation as a first step of promotion. Informing people of the severity of a disease and their vulnerability are the main components of awareness creation. However, risk perceptions, as perceived severity and perceived vulnerability, might not always be the main influencing factors of performing a new behavior, as shown in this study. Interventions should instead be designed based on gathered baseline data to augment the

effectiveness of a promotion campaign and to prevent negative effects of inadequate interventions.

We would like to emphasize that we are not arguing against awareness creation or health-related messages in general. In many cases, such interventions might be very effective. The point we want to make is that what interventions are applied in a campaign and which households are targeted by these interventions should be derived from current data gathered from the target population.

Limitations of the study and directions for future research

The presented study analyzed a real-world promotion campaign, what leads to high external validity, and the relevance for practitioners. However, such studies always bear the risk of shortcomings regarding data quality. The following possible limitations should be kept in mind when the results are applied to other settings.

First, the study was performed in a relatively small community, because only one community filter was installed. Therefore, the number of cases was limited, and there is a risk of dependence of the households. More specifically, the interventions applied to one group might have had effects on other groups. Due to the wide spread of telecommunication devices even in developing countries, this is a problem for any field study. However, in the case investigated, no evidence of such spillover effects could be found. Since all persons received some form of intervention and no physical material was handed out that could have been distributed to others, a spillover effect is rather improbable.

A second limitation of this study is the use of self-reports. With such data, there is always the risk of errors or biases due to misunderstanding, lack of knowledge or opinion by the interviewee, or desirability effects. However, in this study, these effects are largely controlled due to the use of differences over time. Nevertheless, there is the risk of overstating changes after receiving an intervention. Such effects can, however, be excluded, since in most groups the desired behavior is actually reduced. Finally, there might be biases due to training effects with estimation tasks such as the estimation of water consumed. However, all households in this study had already participated in a previous panel, and thus, these training effects should have happened before this study. Further, the interviewers were extensively trained regarding sources of biases and errors. A particular emphasis was put on the estimation of the consumed water. Thus, we are confident in the

quality of the data used in this study. Nevertheless, we recommend reconfirming the findings with data that are not based on self-reports.

Implications for practice

One important finding is that it is possible to change people's perception of price for newly implemented technologies. Even though the price for safe water was at first perceived as too high, the cost persuasion was able to change people's opinion and, therefore, change their consumption behavior. As it is important to implement sustainable fluoride mitigation options, the associated price can be rather high for rural inhabitants. However, before changing the actual costs for purchasing safe water and thus having an unsustainable solution, effort should be made to change the consumer's price perception.

Further, it is important to first investigate the hindering and enhancing factors for people to perform a new behavior instead of the old habitual behavior. Only if these factors are known can tailored interventions be applied. Tailoring interventions does not necessarily lead to higher costs for a campaign. In the case of tailoring cost and vulnerability interventions, promoters visiting the households have to find out only whether there are children at high risk living in a household and whether there is high concern about the price. With two simple questions, promoters can find out which intervention should be applied to the visited household. This procedure can also be used when having identified other influencing factors and implementing different intervention techniques (see Mosler & Martens, 2008).

The problem of fluoride for drinking water quality has been recognized only recently by a broader audience, and further research in this area is necessary. However, with our study, we have added knowledge to the body of research to deepen the understanding of what factors influence the use of a new fluoride mitigation option. Elaborated, evidence-based interventions were developed to mitigate this serious health-threatening problem. Moreover, these interventions were evaluated and, therefore, can now be improved and adapted for further increase in safe water consumption. Our main conclusions drawn from this study are that (1) with behavior change campaigns, behavior can be changed without changing objective barriers, (2) intervention campaigns should be designed based on evidence, and (3) campaigns should be tailored to the target group.

Study 4: Determining the Differential Preferences of Users of Two Fluoride-Free Water Options in Rural Ethiopia

Abstract

In the Ethiopian Rift Valley, 8.5 million people depend on water sources with excessive fluoride. In one rural village, a fluoride-removal community filter was implemented; a personalized reminder was distributed to change people's behavior and increase the usage of the in-village community filter. During this promotion phase, an alternative fluoride-removal option was installed in a neighboring village.

Aim: This study examines psychological factors that explain the differences in preference between the two options and their influence on the usage of the different sources. In addition, the effectiveness of the applied behavior change technique, a personalized reminder, on the use of the in-village community filter was analyzed.

Subject and Methods: In a complete longitudinal survey, 180 households, with access to both mitigation options, were interviewed through structured, face-to-face interviews. Logistic regressions were carried out to reveal factors predicting the usage of the two mitigation options and the effect of the implemented behavior change intervention.

Results: The results showed that the better the taste, the lower the effort and the lower the costs for using the in-village community filter are perceived; in addition, the lower the perceived vulnerability to contract disease, the more the in-village community filter is used. Moreover, it was found that the personalized reminder also had a positive effect on the usage of the in-village mitigation option.

Conclusion: Based on the results, possible recommendations for practitioners and researchers are made to help plan and implement mitigation options.

Keywords: fluoride removal filter; behavior change; perceived costs; perceived taste; effort; personalized reminder intervention

Introduction[4]

The supply of safe water options is a great challenge, especially in developing countries. Worldwide, hundreds of millions of people rely on drinking water polluted by geogenic contaminants, such as fluoride or arsenic. In Ethiopia, 8.5 million people are at risk of developing endemic fluorosis resulting from excessive fluoride uptake through water (Tekle-Haimanot et al. 2006). Fluoride is a naturally occurring mineral that becomes a crucial contaminant of ground and surface water sources at excessive levels. Dissolved in water, fluoride develops its toxic effect on the human body by affecting mainly calcium-containing body parts (McDonagh et al. 2000). As a result, being exposed to high fluoride concentrations in water and having an excessive fluoride intake leads to the development of dental and skeletal fluorosis. The symptoms of dental fluorosis are irregular brown patches on the teeth; symptoms of skeletal fluorosis are bone deformity, limitation of joint movements, and, in the last stage of the disease, crippling. Moreover, people suffering from this disease face psychosocial impacts, such as social exclusion and discrimination (Tekle-Haimanot et al. 2006). Because the medical treatment of fluorosis is very difficult and mostly ineffective, the prevention of fluoride uptake becomes crucial.

To prevent fluoride uptake, people have to stop consuming as much fluoride-contaminated water as possible. For this reason, fluoride-free mitigation options need to be implemented in highly affected areas. One possible option for defluoridation is filtering fluoride using the Nakuru technique, which is comprised of a filter material that mixes bone char (charred animal bones) with calcium-phosphate pellets (Korir et al. 2009). Filtering fluoride with bone char has been found to be an efficient, simple, and comparatively low-cost technology, which is applicable at the household and community level (Kloos and Tekle-Haimanot 1999).

However, just making fluoride-free water available—for example, by installing a community filter—is not enough. People might not consume sufficient filtered water, as using a new technology implies behavior change, from collecting water at an untreated water source to collecting water at a newly implemented safe water source. People might have difficulties adapting to the new behavior because of many different psychological, social, or situational barriers. Therefore, it is crucial that technical solutions are

[4] This study is published: Huber, A. C. & Mosler, H.-J. (2012). Determining the differential preferences of users of two fluoride-free water options in rural Ethiopia. *Journal of Public Health,* doi: 10.1007/s10389-012-0537-4.

accompanied by behavior change interventions that facilitate the uptake of the new behavior and change people's beliefs about the new behavior. Another important point, which should be taken into account when analyzing behavior change after implementation of a new technology, is that people might have various alternative behaviors to choose from. There are always at least two different alternatives: collecting raw water and collecting treated water. If various safe water options are installed in one area, people have even more alternatives. Therefore, it is important for implementers to know not only which safe water option is more sustainable, but also which option is preferred, and for what reason.

Preference factors

To gain insight into why households take up a new behavior and why they prefer a certain alternative, it is important to assess the underlying psychological factors of behavior. Various theories and models of health behavior change provide a wide range of behavioral factors, which should be analyzed. However, health behavior adaptation in developing countries—for example, the uptake of a new safe drinking water option—was carefully depicted in Mosler's systematic approach to behavior change in developing countries (Mosler 2012). To determine the behavioral factors influencing preference and use of an option, we drew on the RANAS Model (risk, attitudes, norms, abilities, and self-regulation) of Mosler (2012). In this model, psychological factors are ordered in five different blocks—risk factors, attitudinal factors, normative factors, ability factors, and self-regulation factors—which comprise all the factors necessary to explain health behavior change (see Albarracín, et al. 2005). Risk factors are divided into perceived vulnerability (a person's subjective perception of his or her risk of contracting a disease) and perceived severity (a person's perception of the seriousness of the consequences of contracting a disease). In addition, a person should have an understanding (knowledge) of how she or he could be affected by a disease through environmental conditions. As attitudinal factors, the taste of the water, perceived costs, and perceived distance are considered, as well as how effortful it is to collect the water from the option. Furthermore, the overall affect refers to feelings that arise when thinking about the behavior. Normative factors regard the descriptive norm (perceptions of which behaviors are typically performed) and the injunctive norm (perceptions of which behaviors are typically approved or disapproved by important others). The ability factors are represented by self-efficacy, which is the belief in one's capabilities to organize and execute the course of actions

required to manage prospective situations. Finally, self-regulation factors put a behavior into practice and help to maintain it; planning is of use as the person plans how to cope with distractions and barriers. In addition, to perform a behavior continuously, the person has to be committed to doing so, and the behavior needs to be remembered at critical moments.

In a study about the use of arsenic-safe water options, it was shown that preference and use of different options can be explained quite well using these behavioral factors (Inauen, Tobias, and Mosler, in press). In the present study, we focused on differences between two options to determine which factors have to be particularly taken into account when introducing a certain choice.

Personalized reminders

Practitioners working in the field of public health in the developing context agree more and more that simply implementing a new technology (e.g., a safe water option) is not enough. People might not use the newly implemented mitigation option for various reasons, which is why it is crucial to combine the provision of hardware with behavior change techniques. Numerous public health interventions have proven to be effective. One intervention technique to change people's daily behavior is the provision of reminders. Reminders or prompts are visual or oral external memory aids that point a person to a certain targeted behavior (Tobias 2009). Tobias (2009) underlines two important main requirements for a reminder to be effective: 1) the information on the reminder must be clearly understandable, so that the person knows what behavior is desired and 2) the reminder must be visible and located where the behavior should be initiated. Various studies in different fields (e.g., pro-environmental behavior or health behavior) have proven, consistently, the effectiveness of prompts as behavior-changing interventions (e.g., Holland et al. 2006; Lewis and Eves 2012). However, to our knowledge, there has not been much research on personalized reminders and their effectiveness to bind people to a certain behavior option instead of an alternative. This study evaluates the effectiveness of a personalized photo reminder on the collection of water at an in-village community filter.

In general, the present study aims to answer three research questions: (1) In which psychological factors do the two preference groups differ? (2) Which psychological factors influence the use of either the in-village community filter or the alternative source? (3) Does the personalized reminder influence people's preference?

Methods

To assess the possible psychological factors that influenced the preference of the two fluoride mitigation options, a longitudinal survey was employed. In May 2010, a fluoride-removal community filter using the Nakuru technique was installed in one rural village, Weyo Gabriel, Oromia Region. The community filter was placed in the center of the village, next to the main public raw water source, a small piped water supply containing 3mg/l of fluoride. The water tariff was set by the local water committee at 0.50 ETB[1] per 20-liter jerrycan. The tariff for fluoride-treated water is twice as high as the tariff for raw water in this village. The community filter is filled with 600 liters of bone char and 900 liters of calcium phosphate pellets. After installation and testing of the filter, the project team organized an inauguration festival for all community members, where speeches were held and a local theater group performed a play to inform people about the fluoride problem. On inauguration day, everybody was allowed to collect water from the new community filter free of charge. The first panel survey took place in September 2010 (P1) and was followed by a first intervention phase (INT1), a persuasion campaign tackling people's perceived vulnerability and perceived price, in October 2010. The analyzed results from INT1 are currently submitted elsewhere. In December 2010, the second panel survey was conducted (P2), followed by the second intervention phase (INT2) and a second post-intervention survey (P3) in February 2011. For an overview of the study design see Figure 1. For the present study, P2, INT2, and P3 are analyzed. During the second intervention phase (INT2), a private organization opened a business and installed another fluoride-removal option in the same project area, approximately three kilometers from the project community filter (CF). The new alternative option was a reverse osmosis (RO) treatment plant, from which the fluoride-free water is sold to the public at a tariff of 0.25 ETB per 20-liter jerrycan.

Study area and sample

The study area is the village of Weyo Gabriel, a typical rural village in the Northern Rift Valley region. Most of its inhabitants are self-sustaining farmers, who live very basically, without running water, electricity, or proper sanitation facilities, in mud and stone houses. The main water sources are public boreholes and private hand-dug wells, which vary in their fluoride concentration between 2 mg/l and 18 mg/l. These levels of

[1] 1 ETB (Ethiopian Birr) = 6 US cents (exchange rate on June 13, 2011).

fluoride content are above the World Health Organization (2004) guideline value of 1.5 mg/l (Tekle-Haimanot et al. 2006).

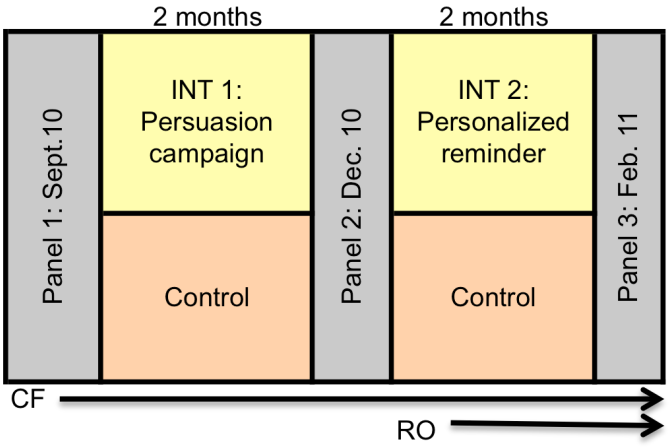

Figure 16 [Figure 1 of Study 4]. Overview of study design including three panel phases and two intervention phases and the installation of the in-village community filter (CF) and the alternative reverse osmosis filter (RO).

The goal of the study was to have a complete survey of all households in the project village. The regional office confirmed a total number of approximately 320 households, from which 120 households were excluded because they owned a fluoride-removal household filter and were part of another study (see Huber et al. 2011). Of the 200 households targeted - the aim was a complete survey - 180 households were found during the first panel survey (P1). In the two followup panels (P2 and P3), eight households were no longer traceable due to migration to town; as such, only 172 households were interviewed.

Procedure and intervention

Because of high illiteracy among the respondents, the data collection was carried out through structured, face-to-face interviews. Ten local college students were recruited as interviewers. Before each survey, the interviewer team attended a four-day training workshop, which consisted of information about fluoride, fluorosis, and the implemented community filter; interviewing skills (e.g., how to conduct the interview and how to avoid asking suggestive questions); and social skills (e.g., how to approach a household and how to handle negative reactions). The households were visited without preannouncement, informed about the study, and asked for consent. The rejection rate was 0% in all panels. The interview was held with the person responsible for water collection in the household. During the surveys, the interviewer team was supervised and monitored.

After the post-intervention survey (P2), the gathered data was analyzed to evaluate the effectiveness of the first intervention phase and to investigate which followup intervention was applied best in order to gain more CF users and avoid relapsing to old behavior (collecting water at the raw water source). The research team, together with the local non-governmental organization, developed the second intervention, a personalized photo reminder. One week before the intervention phase, the community facilitator of the village went to visit as many households as possible to announce the upcoming promotion. He informed the households that in the coming week, a photographer could come to the CF to take photos of people fetching fluoride-free water. People who collected water at the CF the following week were asked if they wanted their photo to be taken. On the reminder the photos were printed and a slogan was added: "Always drink and cook with water from the community filter." The reminders were distributed by the caretaker of the filter. The goals of the intervention were 1) to gain new users by giving them an incentive and 2) to help people remember to collect and consume treated water. During the second post-intervention survey (P3), interviewers checked if households had a photo reminder displayed; 48 households had one or more photos hanging in their house.

Figure 17 [Figure 2 of Study 4]. Personalized reminder: Picture of a woman collecting water at the in-village community filter together with the following message in Oromic and Amharic: "Always drink and cook with water from the community filter." The woman will take this picture to her home as a reminder.

Questionnaire and measures

The structured questionnaires for all panel surveys were designed in English and then translated into two locally spoken languages (Amharic and Oromic), back-translated by two assistants and, finally, revised by the interviewers during training. The questionnaires were pretested with 20 households to ensure applicability and understanding. The questionnaires were designed to cover water collection at different alternative sources, household water consumption, the psychological factors described above, and socio-demographics. Most of the questions were quantitatively measured with 9-point Likert scales for bipolar items and 5-point Likert scales for unipolar items. Factor analyses and reliability analyses (calculating Cronbach's alpha) were executed to scale multiple items.

Usage of treated water source: The dependent dichotomous variable covers two groups: Group 1 used water from the CF and Group 2 preferred collecting water at an alternative source, the new RO plant. Respondents who stated that their households consumed at least 50% more from the CF than the new alternative were allocated to Group 1, whereas households that consumed 50% or more from the alternative source compared to CF were allocated to Group 2. Household that showed no preference for either source (consumed 50% of each or 0% of each) were excluded from the analysis. The current household consumption of treated water was quantified in terms of the percentage of drinking filtered water and cooking with filtered water. First, the person responsible for collecting water reported the weekly purchase of treated water at the CF and the purchase at the new alternative source. Second, the respondent was asked to show the interviewer a regularly used cup, jug, or glass and to assess how many of these cups the entire family drank per day. With the interviewer's estimation of the volume of the named vessel, the total liters consumed per day and household could be calculated. In the end, the percentage of each water source (treated water from the community filter, treated water from the alternative source, and raw water) compared to total water consumption was computed.

Preference factors: All independent variables, except perceived costs, perceived distance, and forgetting, were measured with multiple items, and therefore, included in the analyses as scales. In Table 1, for each independent variable, an example item is displayed. The knowledge variable was measured with five Kprim-style multiple-choice questions (Krebs, 2002). This method is applied if several elements of a subject (e.g., knowledge about fluoride, disease, and prevention of the disease) influence an issue (e.g., people's

overall factual knowledge). All items surveying the psychological factors were measured in reference to the collection of water at the project community filter.

Table 14 [Table 1 of Study 4]. Example items for independent variables.

Scale/factor	Example items	Lowest value	Highest value
Vulnerability	How high or low do you feel are the chances that you could contract fluorosis? The chances are…	-1=much lower than average	1=much higher than average
Severity	Imagine that you contracted skeletal fluorosis; how severe would be the impact on your economic situation?	0=not severe at all	1=very severe
Knowledge	What is fluoride? A chemical. A worm. A parasite. A stone.	4 multiple choice answers; for each 0=answer was wrong 1=answer was right	
Overall affect	How much do you like or dislike fetching water at the community filter?	-1=I dislike it very much	1=I like it very much
Taste	How much do you like or dislike the taste of food cooked with water from the community filter?	-1=I dislike it very much	1=I like it very much
Perceived costs	Do you think that 0.5 Birr for one 20-liter jerrycan of fluoride-free water is too cheap, too expensive, or right?	-1=much too expensive	1=much too cheap
Perceived distance	Is the community filter far from your home?	0=not far at all	1=very far
Effort	Do you think using the community filter is time-consuming?	0=not time-consuming at all	1=very time-consuming
Descriptive norm	How many people in your community fetch water at the community filter?	0=almost nobody	1=almost all
Injunctive norm	Most of my relatives think that I should fetch water at the community filter.	-1=I totally disagree	1=I totally agree
Self-efficacy	I am able to fetch enough water from the community filter for the whole family.	-1=I totally disagree	1=I totally agree
Planning	Have you made a detailed plan regarding what to do if the community filter gets broken?	0=no plan at all	1=a very detailed plan

Forgetting	How often does it happen that you forget to fetch water at the community filter?	0=almost never	1=almost always
Commitment	How committed do you feel to fetching water at the community filter?	0=not at all	1=very committed

Results

The interviews were held with the person responsible for obtaining water; this person was female in 78.6% of the cases and mainly identified as a housewife (48.3%), working in agriculture (32.2%), or informally employed. The mean age of the respondents was 34.7 years (range, 9–80 years). In 57.8%, the interviews were held in Oromic, and 42.2% were held in Amharic. The majority of the interviewees stated that they were Ethiopian Orthodox (84.4%), and there were small groups of Muslims (10%) and Protestants (5.6%). On average, the highest completed school grade was two years (range, 0–12 years). However, 60.6% were unable to read or write. The mean family size of the questioned households was five people, ranging from one to 12 people living in one household.

At P2, the second panel survey prior to the investigated intervention phase INT2 (see figure 1), 34.3% of 172 households stated they only consumed (drinking and cooking) treated water from the CF. An average of 65% (SD=33.8%) of the total water consumption was treated water. After the implementation of the new alternative source and the behavior change intervention (personalized reminder), the average consumption of treated water increased to 87.1% (SD=24.0%). This increase is significant (t= -7.26, df=168, p=.000) and represents a large effect (r = .489). However, 18.6% (n=32) of the total sample preferred the new alternative source at P3, whereas 55.8% still preferred to collect water at the CF (n=96); 25.6% of the respondents did not have any preference (they collected the same amount of water at both sources). The actual consumption at the in-village CF was measured every day and reported to the NGO and research group. The decrease of in-village CF water consumption was visible after the installation of the RO plant in the numbers of sold water per day.

Table 15 [Table 2 of Study 4]. Cronbach's alpha for scales, means and standard deviations for Group 1 (prefers in-village community filter) and Group 2 (prefers alternative source) and independent sample t-test statistics for comparing means between Group1 and Group 2

		Scale	***Group 1***		***Group 2***		***t-test statistics***			
Factor block	Factor	α	*M*	*SD*	*M*	*SD*	*t*	*df*	*p*	*r*
Risk factors	Vulnerability	.898	-.190	.255	-.065	.215	- 2.495	126	.014	.217
	Severity	.742	.912	.101	.919	.150	-.332	126	.740	.029
	Knowledge	--	.580	.209	.709	.199	- 3.046	122	.003	.266
Attitude factors	Overall affect	.908	.836	.137	.471	.448	7.088	126	.000	.534
	Taste	.901	.804	.208	.219	.574	8.499	126	.000	.604
	Perceived costs	--	.328	.673	.633	.571	- 2.298	126	.023	.201
	Perceived distance	--	.609	.251	.586	.243	.461	126	.654	.041
	Effort	.688	.747	.204	.699	.262	1.076	126	.284	.095
Norm factors	Descriptive norm	.748	.479	.168	.391	.143	2.670	126	.009	.231
	Injunctive norm	.969	.727	.250	.225	.592	6.736	126	.000	.515
Ability factors	Self-efficacy	.884	.729	.205	.364	.426	6.472	126	.000	.500
Self-regulation	Planning	.850	.587	.191	.365	.209	5.547	126	.000	.443
factors	Forgetting	--	.060	.198	.344	.405	- 5.258	126	.000	.424
	Commitment	.864	.856	.149	.607	.315	6.013	126	.000	.472

Note: Group 1 (n=96), Group 2 (n=32).

The means and standard deviations of the observed psychological factors for each preference group are displayed in Table 2. To answer research question 1, for comparing the differences between the means of the two groups, independent samples t-tests were calculated. The results also can be found in Table 2.

Nearly all psychological factors differ significantly between the preference groups (Table 2). People who preferred the usage of the CF (Group 1) felt significantly more vulnerable to contracting fluorosis than people who collected water at the alternative option; nevertheless, the effect is rather small (r =.217). Further, Group 1 showed a significantly higher overall positive affect toward collecting water at the CF (with a large effect, r =.534), perceived the taste of water from the CF as much better (with a large effect, r =.604), showed a significantly higher injunctive norm, meaning that more people from their environment think they should collect water from the CF (also with a large effect, r =.515), felt significantly more able to provide their family with treated water, had a higher self-efficacy (represented by a large effect, r = .500), had considerably more detailed plans for overcoming barriers (showing a rather large effect, r = .443), and felt more committed to using the in-village CF (with a large effect, r =.472).

However, in three factors, the two groups do not differ significantly. People perceived skeletal and dental fluorosis as very severe in both groups. Unexpectedly, the groups also did not differ in perceived distance, meaning that both preference groups thought that the CF was somewhat close to their home. Moreover, the effort involved in collecting water at the CF was estimated equally low in both groups.

Households that preferred the alternative source (Group 2), however, showed slightly higher knowledge about fluoride and fluorosis and its prevention than Group 1, though represented by a rather small effect (r =. 266). Moreover, Group 2 perceived the costs for treated water at CF as much higher, even though the effect is rather weak (r =.201). In addition, people from Group 2, by far, forgot more often to collect water from the CF, which is represented with a rather large effect (r =.424).

To answer the second research question and evaluate the main influencing psychological factors that predict the use of either the in-village CF or the alternative source, a binary logistic regression was carried out (see Table 3). Because of the dichotomous dependent variable (use community filter or use alternative option), a logistic instead of linear regression was chosen. A forced entry method was used for the calculation of the regression, in order to include all factors from the behavior model. The results, displayed in Table 3, show which of the psychological factors determine the use of

either one option or the other. After the calculation of the regression, an outlier analysis was undertaken, which resulted in the necessity to exclude four outliers. The eliminated cases showed residuals that exceeded more than two standard deviations and, therefore, would have been misclassified. The resulting regression model showed a high fit (Nagelkerke = 69.2%) and was able to classify 86.7% of all cases correctly.

Table 16 [Table 3 of Study 4]. Logistic regression analysis for variables predicting preference of safe water option (1= uses in-village community filter more, 0= uses alternative source more)

Factor block	Factor	*B*	*SE B*	Exp (*B*)	*p*	*CI (95%) for Exp (B)*
Risk factors	Vulnerability	-3.844	1.943	.021	.048	(0, .964)
	Severity	-1.212	3.950	.298	.759	(0, 658.0)
	Knowledge	-1.282	2.818	.278	.649	(0, 69.56)
Attitude factors	Overall affect	3.614	2.970	37.132	.224	(.11, 12537)
	Taste	5.049	2.018	155.889	.012	(2.98, 8137.9)
	Perceived costs	-2.757	1.211	.063	.023	(0, .681)
	Perceived distance	2.218	2.181	9.188	.309	(.13, 660.7)
	Effort	-7.008	2.967	.001	.018	(0, .303)
Norm factors	Descriptive norm	3.986	3.051	53.841	.191	(.14, 21296.1)
	Injunctive norm	-.525	2.157	.592	.808	(0, 40.59)
Ability factors	Self-efficacy	-3.235	2.705	.039	.232	(0, 7.89)
Self-regulation	Planning	4.173	3.058	64.940	.172	(.16, 26010.9)
factors	Forgetting	-.173	1.245	.841	.890	(.01, 9.66)
	Commitment	3.021	3.15	20.520	.337	(.04, 9843.52)
Constant		-8.304	4.514	---	.066	--

Note: Nagelkerke R^2 = .692, LR-χ^2 = 73.62 with *df*=14 (p=.000), *n* = 120. A forced entry method was used for the calculation.

Four psychological factors contributed significantly to the prediction of the preference groups: perceived vulnerability, perceived taste of treated water, costs of treated water, and effort to collect treated water. The less vulnerable that people felt to contracting fluorosis, the more probable it was that they preferred consuming water from the CF. A positive perceived taste of the water increased the possibility that they would collect more water at the CF. The less expensive that people perceived the price to be at the CF, the more likely it was that they would collect water there. Furthermore, the likelihood that they would collect more water at the CF increased if people perceived that collecting water there took less effort. None of the norm factors or the ability and self-regulation factors

significantly contributed to the explanation of the preference groups. It is noteworthy that the psychological factors self-efficacy, injunctive norm, overall affect, and commitment intercorrelate rather highly (r>.60). Therefore, conclusions regarding the most influential factors should be made with caution. The intercorrelation indicates that all of the factors, on their own, might have a much stronger influence on people's preference, even though they may not reach a significant result in the final regression analysis.

To test the effectiveness of the implemented behavior change intervention (personalized reminder) and answer research question 3, a further logistic regression was calculated. The user group (option 1 or 2) was considered a dependent variable for calculation, and intervention (was a personalized reminder visible in the house or not) was considered an independent variable. The calculated model showed a model fit of 14.3% and successfully classified 77.4% of all cases. Furthermore, the regression revealed that having a personalized reminder at home significantly increased the probability of using the water at the in-village community filter ($B = 2.56$, $SE\ B = 1.04$, $Exp\ (B) = 12.88$, $p = .014$).

Discussion

With regard to research question 1, the two user groups were found to differ significantly in nearly all psychological factors, which implies that there were definitely differences in people's perceptions towards the two water options and that these differences influenced which option they chose. However, to predict which option people choose it is not only necessary to analyze in which psychological factor the user groups differ but also, which of the psychological factors significantly influence people's preference (research question 2). Regarding people's risk perception, both groups were aware of the severity of dental and skeletal fluorosis; however, those who preferred to collect water at the CF felt significantly less vulnerable to contracting fluorosis, which significantly predicted their preference. There might be two reasons for this result. One possible explanation is that people who collected water at the sustainable source, which had existed for nearly two years and was promoted with different campaigns, felt safe using that water and, therefore, felt less vulnerable to contracting fluorosis. People who consumed water from the new alternative, which was not promoted and about which they did not have any information, might not be one hundred percent certain about the effective prevention of fluorosis by consuming that water.

The two preference groups differed in attitudinal factors as well. People who preferred the CF liked collecting water there more and also enjoyed the taste of the water

more than the other group. It has been found in many consumer research studies that positive attitudes towards a product relate positively to purchase intentions and behavior (e.g., Smith et al. 2008). A reverse causality is also possible in this case. The self-perception theory states that people must have a positive attitude toward an object they bought or consumed (Bem 1972). In addition, the perception of the taste of the water was found to influence people's preference of different water types. Researchers found that most preferred water types have medium levels of mineralization and are perceived as tasteless and cooler (Teillet et al. 2009). Furthermore, people who collected water at the CF perceived the price of filtered water as a lot less than the other group did. This might be a result of the first intervention, when people's perception of price was successfully tackled with persuasion (see Huber, Tobias, and Mosler, 2011). Perceived price is a crucial influencing factor of the choices that people make; marketing researchers often find that price perception influences purchase (e.g., Monroe 1973; Lichtenstein et al. 1993).

Not unexpectedly, the two preference groups showed significant differences in both norm factors as well. The descriptive and injunctive norms were significantly higher in the group of people who preferred the more sustainable water source. Consumer researchers also have focused on the role of injunctive and descriptive norms influencing consumer preferences and have found a positive relationship between norms and product preference (e.g., Smith et al. 2008). The higher descriptive norm also can be explained by the fact that people who used the CF more often also more frequently catch sight of important others collecting water there. Although not significantly predicting the preference, the influence of descriptive norm on behavior should not be underestimated. Various studies, also in the development context of safe drinking water, have found the descriptive norm to predict health behavior (e.g., Mosler et al. 2010).

People's abilities and self-regulation factors were found to be significantly higher in the group preferring the CF, even though they were not found to be significant predictors in the regression. As Kiesler and Sakumura (1966) already pointed out, individuals who are bound or committed to a certain behavior avoid behaviors that contradict their commitment and, moreover, are willing to perform behaviors that are coherent with their commitment. Therefore, the high commitment (toward the community filter) in Group 1 is not surprising and supports former research. Consumer researchers have found that even if the purchase of a product evokes health risks (e.g., buying chicken during the chicken flu), a high commitment towards the product leads to an increase in consumption (Graffeo et al. 2009).

Finally, the implemented behavior change intervention, the personalized reminder, was found to influence people's preference positively (research question 3). People who took a photo during the promotion and hung up the reminder in their house preferred collecting water at the CF. The goal of the reminder was to bind people to a behavior that could be performed sustainably and not only for a short time. While taking people's pictures in front of the CF must be one reason for its effectiveness, research on how reminders or prompts operate psychologically is still rare. Mosler and Tobias (2007) however, postulate that the stronger a person feels committed to perform a certain behavior, the more probable it is that a situational cue, like a prompt, reminds the person of the behavior and, therefore, urges the person to act. This implies that a displayed reminder is able to induce commitment and, as soon the commitment is made, the reminder deploys a state of tension within the person if the behavior is not performed (Mosler and Tobias 2007).

Limitations of the study and future research

The present study has some limitations. First of all, it is important to bear in mind that field studies entail unforeseeable events and complications. However, such unexpected incidents can be very interesting and important to evaluate. One limitation of the study is the lack of psychological data regarding the collection at the new alternative, less-sustainable source. All psychological factors depicted in the survey are only measured in regard to the usage of the CF, mainly because the research team was unaware of the implementation of the new safe water option. For future preference studies, it is advisable to evaluate the psychological factors in regard to all alternative behaviors (i.e., the collection and consumption of raw water).

A further limitation is the dependent behavior preference variable, which relies on self-reporting. Self-reported data is always at risk of being socially biased, especially if questioned during an interview. Discrepancies between self-reported behavior and actual performance are known regarding hand washing or water treatment behaviors (e.g. Halder et al. 2010, Arnold et al. 2009). However, due to the high illiteracy rate, interviews were the only possible survey method. The interviewers were trained intensively before each survey and understood the importance of reducing the desirability bias. Regardless, respondents did not find it odd or inconvenient to declare that they also collected water from the alternative option, and the bias is deniable regarding the variance found in the dependent and independent variables.

Finally, it should be mentioned that the longitudinal data was used only to define the preference group and not for the regression analysis. The independent predictors were measured at P3, after the implementation of the new water option and the behavior change technique. Therefore, the results should be carefully interpreted. In a future study, it would be better to a) investigate the behavior and psychological factors toward each alternative behavior and b) analyze the differences over time. Moreover, a future study should be conducted in other areas, with other samples, in order to generalize the results.

Implications for practice

Gaining knowledge about what drives people to use an implemented mitigation option instead of using a newly implemented alternative is crucial for practitioners and implementers, especially if one of the options might be less sustainable than the other. If people change their behavior to collecting water at a possibly unsustainable source and later that source is not accessible anymore, it will be difficult to prevent people from relapsing to the consumption of unsafe, raw water. In the present study, the new alternative source, the RO plant, might be less sustainable than the implemented in-village CF. The raw material (e.g., animal bones) for producing bone char and calcium phosphate pellets used at the CF are locally available at low cost. Further, the income from the water sold at the CF can cover the salary of the caretaker, upcoming maintenance costs, and 50–75% of the cost of replacement of new filter media. The implementers and suppliers, a local NGO, are responsible for the sustainable operation of the filter. By contrast, the newly implemented RO plant bears the risk of not being sustained. One reason is that RO is a high-tech process that requires skilled operators and electricity for operation. Therefore, the capital and operational costs are very high, which makes it impossible to sustain by selling the treated water for the same price as raw water. That is why it was important to promote the more sustainable option for preventing people from contracting fluorosis over the long term.

With knowledge about decisive predictors of mitigation option preferences, specific interventions can be designed to bind a target group to a possibly more sustainable option. If the psychological factors identified as significant are known, then they can be positively influenced through health promotion campaigns.

Attitude factors, such as perceived taste, costs, and effort can be tackled with persuasive communication. As described in the Elaboration Likelihood Model of Petty and colleagues (2004), instrumental attitudes can be influenced with persuasion, using strong

arguments, novel information, and positive outcome scenarios. For persuasion, not only the arguments are important, but also the peripheral cues. The messages should be delivered, for example, by health promoters who are perceived as competent, credible, and respected. In the case of perceived taste, one could increase their taste perception with arguments regarding health. Messages comparing the safe water to medicine might be helpful, by concluding that what is healthy does not always taste good (e.g., cod liver oil), or what tastes good is not always healthy (e.g., sweet soft drinks). Decreasing perceived price could be accomplished with messages saying that it is common that more expensive products also are of better quality, and vice versa (see the intervention study of Huber et al., 2011). If perceived effort must be reduced, one could argue about the benefit of taking more time and effort to provide the subject's family with safe water. Promoters also could help people come up with a weekly plan of when, how, and how much water to collect, in order to save time.

To influence and change people's perceived norms, normative behavior change interventions should be applied. Descriptive norms can be tackled by highlighting how many important others perform the target behavior (Mosler 2012). Making a descriptive norm more salient can be achieved with a public commitment intervention, where people commit to performing a certain behavior and make their commitment public. This can be accomplished with a list of names or signatures of all safe water consumers, displayed at a frequently visited spot in the village. Another option, which would not require people to read or write, are public, noticeable signs (e.g., a flag on the roof, a colorfully painted door), indicating the household's commitment to healthy behavior. According to DeLeon and Fuqua (1995), a public commitment initiates social consequences if the commitment displayed in public is not converted into actual behavior.

Last but not least, the study also shows that the implemented personalized reminder had a positive effect on the preference of the sustainable community filter. This result indicates that reminders or prompts are effective interventions to bind people to a certain behavior and help them not to forget it. Prompts are very popular behavior change interventions because they can be produced and distributed easily, are very cost-effective, and are accepted by all different types of target groups and cultures (De Young 1993; Thyer and Geller 1987).

In conclusion, the present study reveals important insights into why people choose a certain safe water option and how this preference can be influenced by behavior change techniques. Future studies should focus on all different alternative behaviors, so that the

practitioners and implementers can identify crucial social, situational, and psychological factors and influence these with interventions to bind people to the most sustainable mitigation option.

Study 5: Determining Behavioral Factors for Interventions to Increase Safe Water Consumption: A Cross-Sectional Field Study in Rural Ethiopia

Abstract

In developing countries, the lack of safe water options leads to many health risks. In the Ethiopian Rift Valley, most water sources are contaminated with an excess of fluoride. The consumption of fluoride-contaminated water leads to dental and skeletal fluorosis. The article presents an approach to designing community interventions based on evidence from quantitative data. After installing a community filter, a baseline study was conducted in 211 households to survey the acceptance and usage of the filter. To identify important psychological factors that lead to health behavior change, the RANAS (risk, attitude, norm, ability, self-regulation) model was taken into account. Descriptive statistics were calculated for behavioral determinants, and their influence on consumption was analyzed with a linear regression. For every behavioral factor, an intervention potential was calculated. It was found that perceived distance, factual knowledge, commitment, and taste strongly influenced participants' consumption behavior and therefore should be tackled for interventions.

Keywords: interventions; behavior change; drinking water; RANAS; Ethiopia

Introduction[5]

Health issues resulting from contaminated drinking water affect the everyday lives of the citizens of developing countries. For this reason, many safe water options for households and communities are being implemented worldwide. However, research has mainly been conducted on the technical performance of mitigation options. Little research has focused on factors determining the continuous use of safe drinking water options. As a result, different social, situational, and psychological determinants of using mitigation options remain unclear. Therefore, health psychological approaches can be useful to understand citizens' health behaviors in developing countries and successfully implement intervention strategies to change their health-related behaviors (Huber, Bhend & Mosler, 2011; Mosler, Blöchlinger & Inauen, 2010; Tamas & Mosler, 2011). It is important to investigate the determinants of the use of newly implemented safe drinking water options in order to identify hindering and enhancing factors for using a new technology. A clearer understanding of the determinants will enable interventions aimed at promoting habitual use to be designed more successfully (Michie et al., 2008; Mosler, 2012). As several behavior-change researchers point out, the first step in designing interventions is identifying the target behavior and examining the determinants of sustainable behavior patterns so that interventions not only address but also change possible barriers to behavior change (Abrahamse, Steg, Vlek & Rothengatter, 2005; Michie et al., 2005).

In the Ethiopian Rift Valley, with a population of approximately 10 million people, the ground and surface water contains high levels of fluoride because of seismic activity and volcanic rocks (Tekle-Haimanot et al., 2006). The consumption of this water leads to a high risk of dental and skeletal fluorosis. Endemic fluorosis causes not only physical impacts (decay of teeth, joint pain, crippling of bones) but also social and psychological (social exclusion and rejection) ones (World Health Organization, 2004; Tekle-Haimanot et al., 2006). Unfortunately, it has been found that the medical treatment of dental and skeletal fluorosis is difficult and mostly ineffective, especially when the condition has reached an advanced stage (Tekle-Haimanot et al., 2006). For this reason, it is crucial to prevent high fluoride consumption. To decrease fluoride intake, different methods of defluoridating drinking water have been developed. One possible method is filtering the

[5] This study is published: Huber, A. C. & Mosler, H.-J. (2012). Determining behavioral factors for interventions to increase safe water consumption: a cross-sectional field study in rural Ethiopia. *International Journal of Environmental Health Research*, doi:10.1080/09603123.2012.699032

water on a community or household basis before consumption (Kloos & Tekle-Haimanot, 1999).

The goal of this study is to determine the psychological factors that influence people's fluoride-free water consumption and hence can be targeted for behavior-change interventions. For this purpose, the RANAS (Risk, Attitude, Norm, Ability, Self-regulation) model of behavior change (Mosler, 2012) was employed. The behavior determinants in the model are derived from various health behavior change theories, such as the Theory of Planned Behavior (Ajzen, 1991), the Health Action Process Approach (Schwarzer, 2008), and research on habit development (Tobias, 2009). The model focuses on five different factor blocks that determine behavior change: risk factors, attitude factors, norm factors, ability factors, and self-regulation factors. In several publications the factors of the RANAS Model have been verified to influence behavior: for solar water disinfection (SODIS) see Heri and Mosler (2008) in Bolivia, and Kraemer and Mosler (2010) in Zimbabwe; for hygiene behavior see Graf, Meierhofer, Wegelin, and Mosler (2008) in Kenya; for using arsenic-free deep tube wells see Mosler, Blöchliger, and Inauen (2010) in Bangladesh; for the consumption of fluoride-free water in rural Ethiopia see Huber, Bhend, and Mosler (2011).

The focus of this study is to describe a psychological approach to designing an evidence-based community intervention to change health behaviors. This leads to our main research questions: (RQ1) Which psychological factors influence the consumption of fluoride-free water, and (RQ2) which of the influencing factors still have the potential to be changed? The study analyzes data gathered from a survey, describing the sample's mean values of all psychological factors and use of the community filter. Further, the psychological factors are tested in terms of their influence on the targeted behavior, and the intervention potentials of the factors that enhance the consumption of safe water are calculated. Finally, possible intervention strategies are discussed to further increase the use of a newly implemented community filter and the consumption of fluoride-free water.

Methods

Study area and design

The data gathered for this study is part of a cross-sectional research study in Tuchi Gragona, a village in the Northern Rift Valley region of Ethiopia. The study took place in July 2011 three to four weeks after the fluoride-removal community filter was installed. In

the project area, people rely on water sources (one windmill and forty hand-dug wells) that are highly contaminated with fluoride. Very few households have the resources to fetch water from the nearby town of Meki, whose water sources—while still over the WHO guidelines for fluoride (1.5 mg/l)—are not as contaminated as the sources in their village. Tuchi Gragona is a typical rural village in the Rift Valley region inhabiting approximately 2000 people. The village lies ninety miles southeast of the capital, Addis Ababa, and around four miles south of the closest town, Meki. People live in simple mud houses with no electricity or proper sanitation. Most of the villagers work as self-sustaining farmers or daily laborers. There are two public schools (for grades 1 to 8) in the project area. In June 2011, Addis Ababa University and the research team implemented a fluoride-removal community filter based on aluminum oxy-hydroxide filter material, a mixture of aluminum sulfate and sodium hydroxide (Shimelis, Zewge & Chandravanshi, 2006). The filter was installed at the central water source, the Tuchi Gragona windmill. As there is no other village within a distance of four miles, the community filter is mainly for the usage of the inhabitants. The opening ceremony for the filter project was attended by many beneficiaries of the project area as well as by roughly a dozen representatives from the region, the Ministry of Water and Energy, research institutions, and different non-governmental organizations (NGOs). The inauguration included speeches and a performance by a local theater group raising awareness of the fluoride problem. The inauguration festivity was the first and only informational activity in the project village. Unlike the raw water sources, which are free of charge, the community and the regional water committee decided to sell the fluoride-treated water for the price of 25 Ethiopian cents[1] per 20 liters. The water price was set to cover repairs and the salary of a caretaker to ensure the sustainable maintenance of the filter.

Measurement

Because of high illiteracy in the project area, the measurements were made with standardized questionnaires in the form of face-to-face interviews. Through a random route procedure (Hoffmeyer-Zlotnik, 1997), every second household was selected for interviewing. The households were visited without preannouncement. Every participant was informed in detail about the study and asked for verbal consent before starting the interview. The interviews were held with the person responsible for water fetching and

[1] 1 Ethiopian Birr = 6 US cents (exchange rate as of 13.6.2011)

water treatment in the respective household. A total of 211 households (approximately 50% of the inhabitants in the area) were interviewed. Two experts from the NGO translated the questionnaire from English into two local languages (Oromic and Amharic) and back to English for verification. During a two-day training period, the interviewers (local college students) revised every item of the questionnaire in order to ensure consistency of meaning and correct translation. Further, during the training, the interviewers were provided with knowledge about the project area, fluoride, fluorosis, and the community filter. Moreover, social skills and interviewing techniques (e.g., how to approach a household) were covered. The interviewers were supervised by the research team throughout the survey. The questionnaire was designed to cover various factors of interest: demographics, community filter use, consumption of filtered water, and psychological variables of the RANAS model. The application of the RANAS factors was discussed during expert interviews and focus group discussions. As a result the research team decided to evaluate the attitude factors of the RANAS model more in detail, not only differentiating between affective and instrumental beliefs but also perceived taste, distance, costs, and attitude regarding the caretaker were added to the model. Example items for each factor can be found in Table 1.

Table 17 [Table 1 of Study 5]. Example items for each factor used for the analyses, response options and values.

Factors	Example Items	Response options	Values
Behavior	How many jerrycans/barrels of water do you fetch from the community filter per week?	open	
Risk factors			
Vulnerability	How high or low do you feel are the chances that someone in your family will develop skeletal fluorosis? The chances are…	5-point scale from much higher than average to much lower than average	0 to 4
Severity	Imagine that you contracted skeletal fluorosis; how severe would the impact be on your life in general?	5-point scale from not severe at all to very severe	0 to 4
Knowledge	How can you prevent getting fluorosis? With boiling the water before consuming it With filtering the water before consuming it With taking medicine With brushing your teeth more often	For each: 0 = answer was wrong 1= answer was right	0 or 1
Attitude factors			
Overall attitude	Do you think that drinking filtered water is good or bad for your health?	9-point scale from very unhealthy to very healthy	-4 to 4

Perceived distance	Is the community filter far from your home?	5-point scale from very far to not far at all	0 to 4
Perceived cost	Do you think that 0.25 Birr for one 20-liter jerrycan of fluoride-free water is too cheap, too expensive, or reasonable?	9-point scale from much too expensive to much too cheap	-4 to 4
Taste	How much do you like or dislike the taste of food cooked with filtered water?	9-point scale from I dislike it very much to I like it very much	-4 to 4
Normative factors			
Descriptive norm	How many people from your kebele (community) fetch water from the community filter?	5-point scale from almost nobody to almost everybody	0 to 4
Injunctive norm	Most of my neighbors think I should fetch water from the community filter.	9-point scale from I strongly disagree to I strongly agree	-4 to 4
Personal norm	I feel a strong personal obligation to fetch water from the community filter.	9-point scale from I strongly disagree to I strongly agree	-4 to 4
Ability factors			
Self-efficacy	I believe I have the ability to fetch water from the community filter regularly in the next month.	9-point scale from I strongly disagree to I strongly agree	-4 to 4
Self-regulation factors			
Action planning	Do you have a detailed plan regarding when during the day to start collecting from the community filter?	5-point scale from no detailed plan at all to a very detailed plan	0 to 4
Coping planning	Have you made a detailed plan regarding what to do if the community filter breaks?	5-point scale from no detailed plan at all to a very detailed plan	0 to 4
Commitment	Do you feel committed to fetching water from the community filter?	5-point scale from not committed at all to very committed	0 to 4
Perceived habit	How much do you feel that you fetch water from the community filter as a matter of habit?	5-point scale from not at all a habit to a very strong habit	0 to 4
Automaticity	I fetch water from the community filter automatically without thinking much about it.	9-point scale from I strongly disagree to I strongly agree	-4 to 4
Forgetting	How often does it happen that you forget to fetch water from the community filter?	5-point scale from almost always to almost never	-4 to 4

Data analysis

To determine the psychological factors with the strongest intervention potential three different analyses were applied. First, descriptive statistics on the dependent variable (consumption of fluoride-free water) and all psychological variables were computed. Second, a linear regression analysis was carried out to identify significant behavior determinants. The unstandardized regression coefficients (Bs) indicate the slope or strength of association between the determinant and the behavior, or in other words how much the predicted change is in the dependent variable if the corresponding independent variable changes one unit (Field, 2009). In the last step, intervention potentials for the significant determinants were calculated. The sample's mean was subtracted from the factor's targeted value and then multiplied by the regression weight B of the determinant.

Results

Descriptive statistics

The vast majority (95.4%) of the respondents were female and 72.2% illiterate. The rejection rate of interviews was very low (2.8%). Out of the total sample, 45.5% of the households stated to use only filtered water for drinking and cooking. From those who consumed filtered water variably, 20.9% indicated that less than 50% of the water they consumed was fluoride-free water, 25.5% indicated that between 50 and 75% of the water they consumed was fluoride-free, and 8.1% indicated that at least 75% of the water they consumed was fluoride-free water. Only three respondents (1.3%) had not yet consumed filtered water at all. On average, the respondents stated that 89.9% (ranging from 0 to 100%, *Mdn* = 100) of their drinking water came from the filter, but only 62.8% (also ranging from 0 to 100%, *Mdn*= 75) used filtered water for cooking. On average, participants reported buying 4.9 jerrycans per week from the community filter (ranging from 0 to 14 jerrycans, *Mdn*=5). For every person in the household, there was an average of 2.9 liters (0 - 10.7 liters, *Mdn*=2.6) filtered water available per day. However, one person consumed (including both drinking and cooking) an average of 4.4 liters of water per day, thus indicating that almost 50% of water intake still came from fluoride-contaminated water.

The descriptive statistics on the main psychological factors are shown in Table 2. The means of most factors are quite high. Table 2 shows that participants perceive

fluorosis as severe (M = 3.70), have a very positive overall attitude about fetching water at the community filter (M= 3.35), feel that consuming filtered water is a personal obligation (personal norm, M = 3.15), feel highly committed to using the filter (M=3.32), and very seldom forget to fetch water from the filter (M = 0.18). Further, it is seen in Table 2 that participants' factual knowledge about fluoride, fluorosis, and the prevention of fluorosis is moderate (M = 2.94). Moreover, the perceived distance is on average to some extent far from their home (M = 2.35), and the cost of the filtered water is perceived as cheap (M = 1.38). In addition, the taste of filtered water (especially food or coffee made with it) is considered good (M = 2.66), and opinions about the caretaker are positive (M = 2.96). Moreover, people think that at least half of the people they know also fetch water from the community filter (descriptive norm, M = 2.51), and important others approve of their using the community filter (injunctive norm, M =2.80). Further, on average, people feel able to use the community filter (self-efficacy, M = 2.96), plan how and when to initiate the behavior (action planning, M = 2.55), and report detailed plans on overcoming upcoming barriers (coping planning, M = 2.33). On average, people perceive fetching water from the filter as a medium strong habit (M = 2.85) and do it automatically (M = 2.36). However, the mean of the perceived vulnerability factor (M = 0.69) indicates that on average, people do not feel very vulnerable to fluorosis.

Determinants of fluoride-free water consumption

The percentage of fluoride-free water consumption was taken as a dependent variable in a linear regression analysis. The calculated regression displayed in Table 2 shows the factors that significantly predict or influence the consumption of filtered water. An outlier analysis revealed the necessity of excluding eight cases (residuals exceeded more than three standard deviations) from the regression sample resulting in a total sample size of 203. The final model displayed a high explanation of variance (adjusted $R^2 = .568$). The regression analysis revealed seven psychological factors influencing fluoride-free water consumption, four of which influenced the behavior positively and three of which influenced the behavior negatively. From the risk factors, it was determined that it is knowledge that influences the behavior ($B = 3.98$, $p < .01$), meaning that the more knowledge someone has about fluoride, fluorosis, and the prevention of fluorosis, the more filtered water is consumed. Further, two attitudinal factors influence the behavior: perceived distance ($B = - 6.14$, $p < .001$) and taste ($B = 5.59$, $p < .001$). This indicates that the more people feel the filter is far away from their home, the less water they fetch from

the community filter, and the more they like the taste of filtered water, the more they consume it. Further, the examination of the parameter estimates revealed that the descriptive norm has a negative influence on behavior ($B = -5.99$, $p < .01$). That is, the more water people think neighbors are fetching at the community filter, the less they fetch themselves. This negative relationship between the descriptive norm and filtered water consumption was found to be due to a suppressor effect, meaning that one or more factors in the regression suppressed the influence of the descriptive norm. Further analyses revealed that both commitment and overall attitude suppressed the influence of the descriptive norm. Only if people feel committed (value > 3) to using the filter does the descriptive norm positively relate to the behavior ($r = .195$, $p < .05$), and only if they have a positive overall attitude (value > 3) toward the filter is the behavior positively influenced by the descriptive norm ($r = .212$, $p < .05$).

Finally, commitment showed a strong, positive influence on behavior ($B = 11.05$, $p < .01$). Hence, the more people feel committed to using the community filter, the more they consume filtered water. However, perceived habit ($B = 4.75$, $p < .05$) and forgetting ($B = -10.03$, $p < .001$) are also important influential factors of behavior. The less people forget to fetch water from the filter and the more they feel that they fetch water as a matter of habit, the more they consume filtered water.

Intervention potentials

In Table 2, the calculated intervention potentials (IP) are displayed. For each factor, the sample's mean was subtracted from the factor's targeted value and then multiplied by the regression weight of the determinant B (the slope or strength of association between the determinant and the behavior). The higher the resulting value for the determinant, the greater the potential impact of the intervention targeted at changing this factor. The potentials were calculated only for the psychological factors that had a significant influence on the target behavior (see regression analysis). As seen in Table 2, for most factors (except for perceived habit and forgetting), the intervention potentials are high. The calculated potential for perceived habit is moderate (IP = 5.47), mainly because habit is already quite strong, and the influence on behavior is less strong than the influence of other factors. It also seems that participants rarely forgot to fetch water from the community filter, which explains why its potential is low (IP = 1.80). The highest IP was reached by perceived distance (IP = 10.13). Further, knowledge (IP = 8.20), perceived taste (IP = 7.50), and commitment (IP = 7.49) also reached high intervention potentials.

Table 18 [Table 2 of Study 5]. Descriptive statistics, linear regression analysis on the consumption of fluoride-free water, and calculated intervention potentials for significant factors.

		Descriptive statistics						*Regression analysis*			
Factors		***n***	***Range***	***M***	***SD***	**α**	***Items***	***B***	***SE B***	***p***	**IP**
Risk factors	Vulnerability	211	[0, 4]	0.69	0.79	.785	2	-1.13	1.78	.527	---
	Severity	211	[0, 4]	3.70	.471	---		2.18	3.04	.473	---
	Knowledge	209	[0, 5]	2.94	1.07	---		3.98**	1.22	.001	8.20
Attitudinal factors	Overall attitude	211	[-4, 4]	3.35	.531	.814	5	-2.08	3.52	.555	---
	Perceived distance	211	[0, 4]	1.65	1.06	---		-6.14***	1.35	< .001	10.13
	Perceived cost	211	[-4, 4]	1.38	1.60	---		-1.59	.889	.076	---
	Taste	211	[-4, 4]	2.66	.929	.870	3	5.59***	1.50	< .001	7.50
	Caretaker	211	[0, 4]	2.96	.746	.892	3	-3.35	2.51	.183	---
Normative factors	Descriptive norm	211	[0, 4]	2.51	.856	.831	3	-5.99**	2.16	.006	---
	Injunctive norm	211	[-4, 4]	2.80	.757	.857	4	4.81	2.75	.082	---
	Personal norm	211	[0, 4]	3.15	.592	.703	4	-.135	3.66	.971	---
Ability factor	Self-efficacy	211	[-4, 4]	2.96	.647	.805	4	2.29	3.37	.496	---
Self-regulation	Action planning	211	[0, 4]	2.55	1.01	.923	2	2.73	1.92	.158	---
factors	Coping planning	211	[0, 4]	2.33	.961	.686	2	.161	2.43	.947	---
	Commitment	211	[0, 4]	3.32	.533	.743	4	11.05**	3.13	.001	7.49
	Perceived habit	211	[0, 4]	2.85	.964	---		4.75*	2.20	.032	5.47
	Automaticity	211	[-4, 4]	2.36	1.84	.948	2	-.716	.825	.387	---
	Forgetting	211	[0, 4]	.180	.627	---		-10.03***	2.28	< .001	1.80

Note: Means (*M*), standard deviations (*SD*), and value ranges (*Range*) for all factors are provided. For factors with multiple items, Cronbach's alpha (α) for scale reliability and the number of items used is indicated. *B* = unstandardized regression coefficient; *p < .05, **p < .01, ***p < .001; *SE B* = standard error of *B*; *p* = significance level. Adjusted R^2 = .568, *N* = 203. A forced entry method was used for the calculation. Intervention potential (*IP*) = [Maximum value (*Max*) – Mean (*M*)] x unstandardized regression coefficient (*B*).

Discussion

The goal of this study was to reveal the psychological factors that positively influence safe water consumption and have the potential to be changed. The newly implemented community filter seemed to be widely accepted within the community. Of course, the study had a few limitations. One limitation, as with all self-reported data, was the risk of a social desirability tendency in the respondents' answers. However, we attempted to reduce this risk by selecting interviewers who were local and not higher than the participants in terms of status. Moreover, the interviewers passed an intensive training course in which they were sensitized to that bias. During the course, they practiced how to explain to the respondents the importance of answering as honestly as possible. Moreover, interviewers were visited randomly during their work and the first author checked each questionnaire regarding missing data, mistakes, and ambiguities in order to ensure data quality. Unfortunately, there was no alternative method of gathering the data because of the high illiteracy rate in the project village.

As the time of the survey is very early after the installation of the community filter, all users have to be considered as early adopters (Rogers, 2003). Middle and late adopters might have different reasons for using the community filter as it was shown for the adoption of solar water disinfection in Bolivia (Moser & Mosler, 2008).

Further, the present study is only cross-cutting, as it is meant to evaluate the current influencing factors of fluoride-free water consumption in order to determine which behavior change interventions would be most effective. However, it would be valuable to investigate longitudinal data to understand how and why people's consumption behavior changed over time and if the suggested interventions were able to increase filter use and tackle the targeted psychological factors. Future studies should replicate the results using a different setting and sample, because the intervention potentials may not be the same in other Ethiopian villages. Moreover, in a different setting there might be other underlying psychological factors that are missing in the RANAS model and if added could further increase the model's validity.

Implications for practice

With the knowledge of the decisive determinants of filtered water consumption and their intervention potentials, specific intervention strategies can be designed to enhance the usage through influencing these psychological factors.

The highest intervention potential was reached by perceived distance, which was as expected. The majority of people in this village have access to a private or shared hand-dug well. Therefore, the walking distance to such a well is very short and requires a minimal amount of effort. A similar result was found in a study about the usage of arsenic-free deep tubewells in Bangladesh, where the time needed to collect water at a tubewell significantly influenced the use of that well (Mosler et al., 2010). Perceived distance is, on the one hand, a situational factor, but changing the situation would require installing more community filters, which, due to financial constraints, is not feasible. On the other hand, perceived distance is an attitudinal factor. Therefore, changing people's beliefs or attitudes about the distance might be more useful and cost effective. This could be done with persuasive communication. Strong arguments must be found and delivered by, for example, health promoters to decrease people's perceived distance and increase their willingness to walk longer distances for fluoride-free water. Possible arguments could include the value of walking longer for safe water and a healthy family. Further, people's perceived effort could be reduced by developing a weekly plan regarding when and how much water has to be fetched each week instead of walking there every day.

Furthermore, perceived taste also showed the potential for change. However, the taste is, in general, perceived as good. This result implies that either people do not associate the salty taste with bad taste in general or that compared with the taste of raw water, the filtered water is good. Several studies on behavior change regarding water consumption found perceived taste to be influential (e.g. Huber et al., 2011; Heri & Mosler, 2008). Changing the actual taste of the water is not that simple. Regarding the aluminum oxy-hydroxide material, it is known that (especially at the beginning) the water might taste a bit salty due to elevated sulfate concentrations. Thus, if people are informed that the taste will get better after a while, it might motivate them to use the filtered water continuously. Nonetheless, the survey took place three to four weeks after the inauguration when the taste might still have been salty. By now, the taste should have improved notably. However, perceived taste is again an instrumental

attitude that can be changed by persuasion (Petty, Rucker, Bizer & Cacioppo, 2004). Strong arguments have to be applied to persuade people about the health aspect of the less tasty water. Comparing it to medicine might help in order to help people conclude that what is good for your body does not always taste good (e.g., koso, a traditional plant to treat worms) and vice versa (e.g., sugar).

In addition, knowledge was found to have a substantial intervention potential. Knowledge being one of the influential behavior factors was also found in a study about the uptake of solar water disinfection (Graf et al, 2008). Increasing people's knowledge about fluoride, fluorosis, and especially the prevention of fluorosis can be transferred by information interventions (e.g., workshops for community members) (Mosler, 2012). Heads of household and their wives (who are normally responsible for water treatment) should attend educational training in which they receive factual knowledge. The workshop intervention could even be combined with a commitment intervention, because commitment also showed a respective intervention potential. At the end of the workshop, for example, people could form an intention to always drink and cook with fluoride-free water and express their plan in public, in front of all other community members. Committing oneself in public evokes not only a personal feeling of commitment but also a social pressure to do what was communicated (Mosler & Tobias, 2007).

Further, perceived habit was found to influence people's water consumption. A similar study about the usage of fluoride-removal household filters in Ethiopia found that the more people perceive the usage of the filter as a matter of habit, the more possible they exclusively consume filtered water (Huber et al., 2011). To tackle people's perceived habit, prompts or implementation intentions could be effective intervention strategies (Tobias, 2009). Prompts are external memory aids that remind an individual to execute a certain behavior at a specific time (Dahlstrand & Biel, 1997). Prompts can be easily designed and distributed by health promoters, who inform the household where to install the prompt so that it is seen every day and reminds people to perform the targeted behavior (e.g., fetching water at the community filter). Personalized prompts can also be very effective and inexpensive. People could have their pictures taken at the community filter, and a slogan could be inserted in order to remind people to always fetch fluoride-free water. Such a personalized prompt would also strengthen people's commitment to fetching water from the community filter. Another effective tool is forming implementation intentions. Implementation

intentions help people to perform a specific behavior by making concrete plans of actions that specify *how*, *where,* and *when* actions should be performed to achieve an intended goal (Gollwitzer, 1999). In this context, it should be discussed with the household *when* is the best time to fetch water from the community filter in order to fit their daily or weekly routines and *how much* water they have to fetch to cover the household needs. At the same time, it should be discussed *how* to incorporate the consumption of filtered water in their daily activities. As people are in the fields most of the day, it would be appropriate to make plans regarding how they can take filtered water with them.

Conclusions

This study on the usage and acceptance of the newly implemented community filter reveals important insights regarding the determining factors of fluoride-free water consumption. Even though a great number of community members were already adapting well to the new behavior, the consumption of fluoride-free water still needs to be increased. The mentioned intervention strategies (persuasive communication, educational workshops, commitment, prompts, and implementation intentions) could be implemented together or separately to further increase consumption. More precisely, we recommend a collaboration of different stakeholders to implement further fluoride mitigation options. On the regional level, one should discuss which mitigation options are accurate and feasible for a given contaminated area. Further, an implementer is needed, for example a local NGO, who should be in charge of a) communicating with the community and its leaders about the plan and organization, b) organizing the construction of the community filter, and c) designing and implementing effective interventions to change people's water consumption behavior. The results of this study are important for the implementer organization in order to know with which psychological interventions people's behavior can be changed successfully.

Moreover, in Ethiopia, every area has an assigned water bureau, which should be responsible for managing and maintaining the new safe water source. On the national level, it is necessary to further improve access to fluoride-free water for people living in the contaminated Rift Valley Region. Even though considerable achievements have been made since the detection of fluoride in urban areas, effective, sustainable and well-maintained mitigation options in rural areas are still rare (Tekle-

Haimanot et al., 2006). The National Fluorosis Mitigation Project Office is planning to develop a strategy plan that describes future steps to improve the access to fluoride-free water in the Rift Valley region and other fluoride-affected areas in Ethiopia.

To conclude, the newly implemented community filter seemed to be widely accepted within the community. However, people's perceptions (regarding distance, taste, knowledge, habit, and commitment) should be further influenced in order to increase their fluoride-free water consumption and prevent the development of severe fluorosis.

Overall Discussion

Overall, the five studies reveal that the uptake and continuous use of fluoride mitigation options are influenced by psychological factors proposed by Mosler's (2012) *RANAS* model of behavior change. Moreover, the factors of the model were able to explain not only people's consumption behavior, but also their preference for one or the other of the two different mitigation options. Even though the *RANAS* factors appeared to influence different water-related behaviors in various developing countries, it is necessary to study the specific behavior change model in a given context for the target behavior and population. During formative research (i.e., qualitative in-depth interviews), researchers may detect other important hindering or enhancing factors for their target population to perform a specific behavior. Therefore, it has to be taken into account that the *RANAS* model is a conceptual behavior change model that allows adding extra factors or dividing factors for more detailed description.

Study 1 explains the psychological factors that influence a household's exclusive use of filtered water. For this purpose, a wide range of factors was analyzed. The attitudinal factors from the *RANAS* model were described in more detail in order to identify the most influencing factors for filtered water usage. The perceived taste and perceived costs of filtered water were evaluated separately instead of declaring them as affective or instrumental beliefs. Apparently, these two factors showed major influence on exclusive filter use. The normative factors were augmented by the status norm, which was found to be an important factor due to the cultural custom of Ethiopia having frequent guests for coffee ceremonies. Study 1 clearly shows the importance of formative research. Three of the five most influencing factors of exclusively consuming filtered water were added to the *RANAS* model only due to the knowledge gained from the qualitative research and pretests.

The *RANAS* model covers most of the factors depicted in Study 2, except the communication factor. In fact, none of the models proposed in this thesis includes communication as an influencing factor. Even though Study 2 was able to show the effectiveness of two different interventions, it failed to reveal the modes of operation of the behavior change techniques. Taking the *RANAS* model into account, the influence of the social prompt should also have been tested on action planning and self-efficacy, as it is a planning and ability BCT according to Mosler (2012). Moreover, it would have been interesting to evaluate the long-term effect of the social

prompt interventions, even though they are not expected. Also, the workshop involving commitment should have followed the *RANAS* model in testing the influence on vulnerability, severity and knowledge (as an information BCT) and the influence on descriptive and subjective norms (as a normative BCT). It is anticipated that the pledge at the end of the workshop (public commitment) will have a long-term effect on behavior change. However, long-term effects have yet to be analyzed. Even if Study 2 did not find any additional behavior change effects while implementing the workshop including commitment after the social prompt intervention was applied, the combination of the two BCTs might lead to a long-term and sustainable behavior change. Future research should focus on long-term effects of BCTs and their modes of operation.

Study 3 also explains fluoride-free water consumption successfully with the factors from the *RANAS* model. The most influential factors are not only identified, but also their potential to be changed is evaluated. The results showed that the perceived costs and perceived behavior control have the highest intervention potential. They are, therefore, tackled by a BCT. The goal of the designed BCT (persuasion on perceived costs) was considered not only as a technique for increasing the consumption behavior, but as a first step to decrease people's perceived costs of filtered water. Study 3 was able to show that an evidence-based BCT is able to change behavior by changing the targeted psychological factor. Moreover, Study 3 reveals the importance of evidence-based behavior change campaigns. Campaigns designed on a common approach are not effective when targeting a factor, which has no intervention potential. Finally, Study 3 introduces successfully the matter of tailoring BCTs to the target population. The results showed that tailoring interventions is not only more effective but in some cases also crucial. Receiving messages, which do not fit the targets needs, can evoke negative effects as was shown in Study 3. Therefore, in my opinion, interventions that are untailored can fail or even revoke a behavior change.

Study 4 uses the *RANAS* factors to describe the preference between two mitigation options. To analyze why people prefer a certain safe water option is important for practitioners when different options are available but only certain options are sustainable. Additionally, Study 4 evaluates the implemented intervention: a personalized reminder. The planning BCT was effective in binding people to the original, more sustainable water source. The message on the reminder was definitely a major, decisive factor. The personalization through the photo of the recipient collecting

water at the sustainable option was expected to be very effective. Personalizing a prompt does not require much additional time or cost and therefore is an effective and feasible way of influencing someone's preference and binding people to a safe option. According to Mosler (2012), the personalized reminder should have influenced people's commitment and remembering positively and, therefore, influenced their preference. However, these effects were, unfortunately, not tested. A future study should evaluate the long-term effect of binding users to a certain mitigation option and analyze the BCTs mode of operation.

Study 5, again, uses the *RANAS* model to determine the psychological factors, which lead to higher behavior change and further are tested for their potential to be changed. New in Study 5 is the use of a new filter material (AO media) for the community filter and the study region. However, similar factors were found to influence people's fluoride-free water consumption, such as: taste, commitment, or perceived habit. The calculated intervention potentials showed that BCTs should be designed to augment people's perceived distance to the filter, factual knowledge, perceived taste, and commitment. Due to practical reasons the proposed interventions could not have been implemented. In a future study the BCTs should be applied and evaluated for their effectiveness and influence on the targeted factors.

Research Questions

In the following section the stated research questions for the five presented studies will be answered.

Study 1

The research question (RQ1) of Study 1 stated: **What are the enhancing and hindering psychological factors of fluoride-removal household filter use?** Study 1 showed that four psychological factors were found to enhance the use of a fluoride-removal household filter: perceived taste of filtered water, how proud someone is to present filtered water to guests (status norm), perceived filter capacity (perceived behavioral control), and perceived habit of filling the household filter. The study revealed important insights into how to implement and promote a new technology, such as a household device successfully. The results from Study 1 were taken into account in designing and developing behavior change campaigns to further increase the

use of the household filter and consumption of fluoride-free water. These campaigns were implemented and evaluated in Study 2.

Study 2

Study 2 involved the examination of five research questions focusing on the effectiveness and modes of operation of two different behavior change interventions comparing to a technical intervention only. The first research question was (RQ1): **Is a technical intervention (providing a household filter) enough to induce behavior change or are additional psychological interventions necessary?** The results of this study showed that only implementing a new device is not enough to induce a behavior change. The provision of a household filter should be accompanied by a promotional activity in order to ensure sustainable usage of the new technology. Further, the study evaluated behavior change interventions and asked (RQ2): **Does a social prompt lead to behavior change?**The evaluation indicated that households who received a social prompt intervention increased their consumption of filtered water and, therefore, changed their behavior successfully. RQ3 asked: **How does the social prompt psychologically operate?** Unfortunately, the study did not succeed in answering this question. The hypothesized factors—remembering and perceived habit—which were thought to be influenced by the social prompt, showed no change after applying the intervention. One main reason for that finding is that both factors were already high before the intervention. Additionally to the social prompt intervention, an educational workshop involving commitment was applied. RQ4 asked: **Does an educational workshop followed by a public commitment lead to further behavior change?**The results showed that if the workshop involving commitment was applied to households who took part in the social prompt intervention, no further increase of fluoride-free water consumption was found. The result indicates that the workshop as a follow-up intervention induced no further behavior change. However, if the workshop with commitment was applied without any former intervention phase, behavior change was successful. The last research question (RQ5) stated: **How does the workshop with public commitment psychologically operate?** It was hypothesized that the workshop with public commitment operates through commitment and communication. Nevertheless, only a marginal influence on communication was found, as people's commitment was already rated high before the workshop.

In conclusion, Study 2 was able to show that only implementing a new device is not enough but accompanied by a social prompt intervention can ensure behavior change. Also the workshop with public commitment was successful in increasing safe water consumption, but not if it is applied as a follow-up intervention. Unfortunately, the questions of how the behavior change interventions psychologically operate remain unanswered. Further research in this area is required.

Study 3

Study 3 evaluated three main research questions. RQ1: **Is it possible to change behavior only by changing subjective perceptions and beliefs even if the objective circumstances remain the same?** The results from the study clearly indicate that behavior change interventions, such as a persuasion campaign, are able to change subjective perceptions (i.e., perceived costs) without changing the circumstances (i.e., actual price of filtered water). This finding indicates the effectiveness of a persuasion campaign focusing on people's price perception. A further research question was (RQ2): **Does it pay off to design behavior-change campaigns based on evidence and to tailor interventions to the target group or apply an intervention only to a predefined selection of the population?** The findings of Study 3 confirm that designing interventions based on evidence pays off. Evidence-based campaigns were shown to be more effective in changing people's behavior than interventions not based on evidence. Further, tailoring interventions to the target group also demonstrated more effects in changing people's behavior than interventions, which were applied randomly. An evidence-based tailored intervention campaign takes the target person's need into account and, therefore, appears to be a more effective way to ensure behavior change. Further, RQ3 asked: **Are there differences among people who do not receive any intervention, people who receive inadequate interventions or people who receive an intervention that does not fit regarding changes in the target behavior?** The results showed that there are practically no differences in behavior change among the control group and the group who received inadequate interventions. Both groups decreased their safe water consumption over time.

To conclude, Study 3 demonstrates that behavior change interventions can alter people's perceptions without changing objective barriers, that interventions should be designed based on evidence, and should be tailored to the target group to ensure successful behavior change.

Study 4

Study 4 raised two research questions. RQ1: **Which psychological factors determine the preference between two fluoride mitigation options?** Four psychological factors were found to contribute to the prediction of the preference: perceived vulnerability, perceived taste of treated water, costs of treated water, and effort to collect treated water. The results showed that the less vulnerable people feel about contracting fluorosis, the better the taste, the lower the costs and the lower the effort is perceived, the more probable they will consume water from the sustainable option. The second research question was: **How effective are personalized reminders to bind people to a more sustainable water option instead of changing to another less sustainable option?** The results of Study 4 indicate that people who received a personalized reminder were more likely to use the more sustainable source instead of changing to a new option. This finding indicates that the applied intervention was able to bind people to the target behavior.

Study 5

Study 5 also raised two research questions. RQ1: **Which psychological factors influence people's fluoride-free water consumption at a newly implemented community filter?** The analysis revealed that seven psychological factors significantly influenced the use of the community filter. Knowledge, perceived taste of filtered water, perceived habit of collecting water at the new source and commitment were found to be enhancing factors of consumption, whereas perceived distance, descriptive norm and forgetting were found to be hindering factors of consumption. The second question raised (RQ2) was: **Which are the psychological factors with the highest potential to be changed?** From the above-mentioned influencing factors, the one with the highest intervention potential was perceived distance. Additional factors with high potential included: knowledge, perceived taste and perceived habit. To further increase the consumption of fluoride-free water in this population, behavior change interventions should be designed to tackle these four influencing psychological factors.

Limitations and Open Issues

There are some limitations to this thesis. Three different fluoride mitigation options were analyzed in this thesis: the community filter and the household filters

using the Nakuru technique; and the community filter using the AO filter material. The goal for each option was to determine the influencing psychological factors in order to design accurate behavior change interventions, further implement, and, finally, evaluate them. However, for the last option, the AO community filter, the implementation and, therefore, also the evaluation of the chosen interventions failed. One reason was the late (more than one year later than originally planned) construction and opening of the AO filter. The main reason, however, for not implementing any promotional campaigns was that the future of the filter was not secured, due to the lack of additional filter material for replacement after saturation. However, the proposed behavior change techniques in Study 5 to further increase the usage of the newly-implemented community filter would have been applied if the filters sustainability had been ensured.

Further, it should be mentioned that, for all studies, the sample sizes were limited and could be regarded as a limitation. Nevertheless, only households with access to a fluoride mitigation option could be included in the samples and the funds for implementing the different filters were limited. However, studies 1 to 4 were aimed at complete surveys, including all households with access to a filter. Due to lack of time and funds Study 5 evaluated only 50% of the population.

Future researchers might implement only one type of mitigation option in various study areas (i.e., other regions or countries), in order to gain more knowledge about different influencing behavior change factors and to identify common factors to generalize results. Further, the modes of operation of behavior change interventions should be addressed more often, as the understanding of how an intervention affects a person can improve the design of an intervention and, therefore, its effect.

All in all, this thesis was able to provide important insights into why people use or do not use a newly-implemented technology, and how the identified psychological factors can be changed successfully with behavior change interventions.

Implications for Practice

The knowledge gained from the five presented studies aids in the formation of implication strategies for practitioners and researchers.

How to properly implement household filters

The results of Study 1 lead to several implications for practitioners. First of all, to ensure the feeling of being able to produce enough filtered water for a whole family, the filter buckets should be big (approximately thirty-liter storage capacity). If a household with more than four family members purchases a filter with a ten-liter storage capacity, the person responsible for water treatment might feel discouraged and not able to filter enough water for everyone in the family. Bigger buckets with more storage room for filtered water increase people's perceived behavioral control.

Further, to create the sense of ownership, a price for purchasing the household filter should be set. People might not be able to afford the full initial costs of the filter but they should pay a contribution. Purchasing the filter instead of receiving it for free will not only make the beneficiaries feel independent from charity but also increase their commitment to using the filter.

As it appears that the taste of filtered water is an important influencing factor of consumption, the household filter should use a filter material that does not change the taste of water or at least should not make it worse. If the filter material changes the taste of the raw water negatively adding a taste enhancer to the filtering process might be a consideration. If the taste of filtered water is perceived as bad by the users, behavior change campaigns must focus on changing this negative attitudinal belief, for example, through persuasion.

For the distribution of the household filters, it is necessary to include a small training program regarding how to use and maintain the filter properly. Buyers should have the option of asking questions about uncertainties of handling the filter as well as about health effects. In order to ensure that the whole family benefits from the filter, the distributers should advise filter users about how many times they need to fill the filter per day to supply every household member with safe water. A rule of thumb can be applied. For every adult (above 16 years) living in the household, the filter should be filled once per day. For every child, half a filling should be counted. Hence, during the distribution, every purchaser should state how many adults and children live in his/her household, and then receive a number of filling times per day.

How to further increase and maintain household filter use

There are few implications that can be drawn from the findings of Study 1 and Study 2. Once the filter is purchased, it will be definitely used at the outset. Having a new device at home is interesting and therefore there is a desire to try it. However, there might be cases where filter use declines rapidly after the initial excitement, or cases where an insufficient amount of filtered water is produced because the filter is not filled at the correct moments or not regularly. A habit of filling the filter has to be established and/or increased. This can be done with different behavior change interventions as for example prompts/reminders or daily routine planning. Even though the person responsible for water treatment might know how many times the filter should be filled to ensure enough filtered water for the whole household, it might be difficult to remember to fill the filter or to fill it at proper moments during the day. Thus, it is important to help beneficiaries plan their filling moments. A daily routine planning can be applied (i.e., when during the day is a good moment to fill the filter and how does the filling fit into the daily routine of the caretaker). After planning the filling moments, these moments should be prompted. This can be done with a social prompt: Another person in the household may remind the caretaker to fill the filter according to the daily routine plan.

Another way to further increase filter use is to make the status norm (what guests think about having filtered water) more salient. Filter owners feel proud to offer filtered water to guests. This pride could be made public with a public commitment intervention. When important others learn where the households are who can offer safe water, filter owners will make sure that they always have filtered water in their buckets and therefore fill the filter more often. A public commitment intervention can be combined with a workshop (with knowledge transfer) concluding with an oral pledge in front of others to always have filtered water at home.

The combination of a social prompt and a workshop including commitment does not seem to have additional effect. Therefore, applying one intervention might be enough to increase and maintain people's filter use. To achieve best possible effects, the interventions (prompt or workshop with commitment) should be tailored to the target group. Based on data, households that need to increase in habit or for which households it is important to present filtered water to their guests can be identified.

How to properly implement community filters

The results from Study 3 bare important insights for practitioners as well. The usage of a community filter should be promoted only if the filter itself is reliable and sustainable. It is unethical to promote a behavior that cannot be maintained. Sustainability also means being able to cover running cost, maintenance costs, and costs for filter media replacements. In order for the community not be dependent on implementing NGOs, the filtered water must be sold at a certain price. Furthermore, a community filter also requires a reliable caretaker, someone who is always available during opening hours. People who have access to the community filter should have the chance to collect water at the filter regularly in order to form a habitual behavior.

As for the household filters, the taste of the water from the community filter should be perceived as good (or at least not worse than the taste of raw water).

The target population having access to the filter should have profound factual knowledge about fluoride, fluorosis, and the prevention of fluorosis. This knowledge should be communicated at an early stage, for example, during the inauguration ceremony of the filter. However, there will be always people who are not able to attend or do not want to attend the opening and, consequently, are not able to receive proper information. Therefore, it is important to make a concerted effort to reach these kinds of people too, for example, with an informational campaign prior to the inauguration.

The perceived high effort required to collect water at a community filter and a perceived long distance to walk to the filter were found to be hindering factors for using the filter. The easiest way to avoid that problem is to place the community filter at a central location in a village next to the main raw water source. As a result, the new behavior (collecting water at the community filter) is not different to the old behavior (collecting raw water at the main source).

How to further increase and maintain community filter use

Study 3 and 4 give insight into further implications for maintaining filter use. The perceived cost of filtered water is a crucial factor influencing people's consumption. Households who perceive the price as too high might not collect water at the community filter at all and continue to consume contaminated water. However, a price perception can be changed by a persuasion campaign. As well, the actual price does not have to be lowered and the sustainability of the filter jeopardized. Calculating

a personal water budget for each family and demonstrating that the actual costs for providing safe water to the whole family are not as high as expected can decrease people's cost perception and, therefore, increase their consumption.

Further, high commitment towards the community filter influences its use positively while high forgetting influences its use negatively. Increasing commitment and decreasing forgetting can be achieved by implementing a personalized reminder. Such a photo prompt also increases people's perceived habit of continuously collecting water at the filter. Furthermore, it also binds people to the community filter and prevents them from changing to another source which might me unsustainable.

If people still perceive the distance to walk to the community filter as too long and the effort to collect water there too high, even though the filter was placed at a central location, these factors can be changed. A persuasion campaign with strong arguments can be applied. Promoters could also help people by creating weekly plans including when and how to collect water most efficiently or to include neighbours for collecting water on turns or share donkey carts for water transportation.

What to implement, household or community based options

How do implementers or practitioners decide if they should implement a community or household mitigation option? There are advantages and disadvantages to both options (for an overview see Table 19). One main goal should be to provide fluoride-free water for all inhabitants of regions with excess of fluoride in ground and surface water and lacking alternative safe sources. As already mentioned, in the Ethiopian Rift Valley, a great number of people (approximately eight million) are at risk of drinking contaminated water (Tekle-Haimanot, 2006) and therefore in need of fluoride-free water options. In my opinion, community filters are definitely more feasible to implement or distribute. Moreover, for implementers the monitoring of the filter is easier as is the replacement of the filter media after saturation. However, in areas or villages with very scattered households, a community filter might not be the best option due to long distance required for collecting water. Therefore, I think, from a technical point of view, the decision whether to implement household or community filters depends on the target village.

Table 19. Overview of advantages, disadvantages, influencing factors and possible interventions for community and household filter implementation.

	Community filter	Household filter
Advantages for implementers	- Monitoring and replacement of media easy - Higher use through community	- Applicable in low density areas
Disadvantages for implementers	- Not applicable in low density areas	- Monitoring and replacement of media difficult and time-consuming
Advantages for beneficiaries	- Only small expenses every other day	- Can be used every day independent from financial situation - High use due to the commitment through purchase
Disadvantages for beneficiaries	- No filtered water if no cash is available	- High expense when replacement is due - Lower use after first replacement payment
Psychological factors influencing usage	- Perceived taste - Perceived costs - Commitment	- Perceived taste - Perceived costs - Perceived habit
Possible interventions to increase and maintain usage	- Persuasion campaigns - Public commitment - Educational workshops	- Persuasion campaigns - Daily routine planning - Prompts

From a psychological point of view, there are other advantages and disadvantages. Collecting filtered water at a community filter implies that a family has expenses every day, or at least every other day. Even though the amount might be small people can collect filtered water only if they have cash that day (see Study 3). During the dry season this is not always the case for many of the farmer families. Purchasing a household filter, on the other hand, needs an initial higher expense. As well, every six to twelve months another medium expense is required for replacing filter media (see Study 1). The implication is that poor families without savings are not able to afford the purchase of a filter in the first place. Households who can afford a filter can produce safe water everyday without extra costs until the day of media replacement. They, therefore, might perceive the overall price of filtered water lower than use of a community filter. Further, the commitment made through the purchase of

the household filter implies a higher use of the filter (see Study 1). The major disadvantage of the household filter, however, is the extra expense when media replacement is needed. If the replacement time is during dry season when money is scarce and the savings from the harvest are gone, people tend to give back their household filter because they cannot afford the media replacement.

Comparing the household and community filter samples over time, it has been shown that, after two intervention phases, there are more households using the community filter which consume 100% fluoride-free water than households owning a household filter (see Study 2 and Study 4). One explanation for this results might be that after replacing one batch of filter material, household filter users might have understood, that the more they use the filter, the sooner they have to pay for another replacement.

There are two influencing behavioral factors that are equally important for household and community filter users: perceived taste and perceived costs. This indicates that if both these factors can be kept or made positive, a higher use of both filter options is expected. Both are attitudinal factors, which can be changed by behavior change interventions, i.e., persuasive communication. Hence, when the implementing organization decides to implement both options in different areas they might even apply the same promotional activities in both areas, focusing on perceived costs and taste.

Interventions aimed at increasing household filter usage should focus mainly on strengthening people's habit of filling with daily routine planning and prompts. Whereas, interventions to increase the collection of filtered water at community filters should tackle people's feeling of commitment with public commitment campaigns. Both campaigns are feasible in high-density areas. With scattered households it is necessary to work with either promoters or community meetings. Also daily routine planning can be accomplished only with promoters doing household visits. This is much more costly than distributing prompts or public commitment signs.

All in all, it is difficult to say which is the better option: a household or a community filter. Both are highly accepted and used by the communities but the feasibility of implementation and promotion depends on the target area.

Conclusion

The *RANAS* model of behavior change was able to describe successfully the usage of fluoride-removal household and community filters in six different villages, two different regions, and using two different filter materials. Furthermore, the factors were used to identify the preference for either a sustainable or a less sustainable mitigation option. However, in certain situations, factors may have to be added to the RANAS model (e.g. social support, status norm) or existing factors have to be divided (e.g. perceived distance, costs, effort, taste of water) to gain a deeper understanding of the influencing factors. The results of the five studies can be summarized as follows:

1. Formative research (e.g., qualitative, in-depth, or experts interviews) is important for complementing the *RANAS* model with potentially important factors.
2. Implementing a new device, such as a filter, should be accompanied by psychological interventions to ensure sustainable behavior change.
3. A baseline survey is necessary to design evidence-based interventions.
4. Not only the influencing factors are important for designing a behavior change campaign but also the factors potential to be changed.
5. Tailored interventions are more effective than interventions that do not fit the targets' needs or characteristics.
6. Applied behavior change interventions should be evaluated not only on their effectiveness regarding behavior but also on their influence on the targeted psychological factors to understand their modes of operation.

These results imply necessary steps towards successful and sustainable behavior change. Therefore, the knowledge gained from the five studies helps to improve the successful implementation and sustainable use of fluoride mitigation options. Further, the behavior change process can be improved due to the insights of the studies. Feasible and effective behavior change interventions were identified and, therefore, can be designed similarly and applied to other populations.

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Appendixes

- Appendix A: Supporting Information for Study 2
- Appendix B: Supporting Information for Study 3

Appendix A: Supporting Information for Study 2

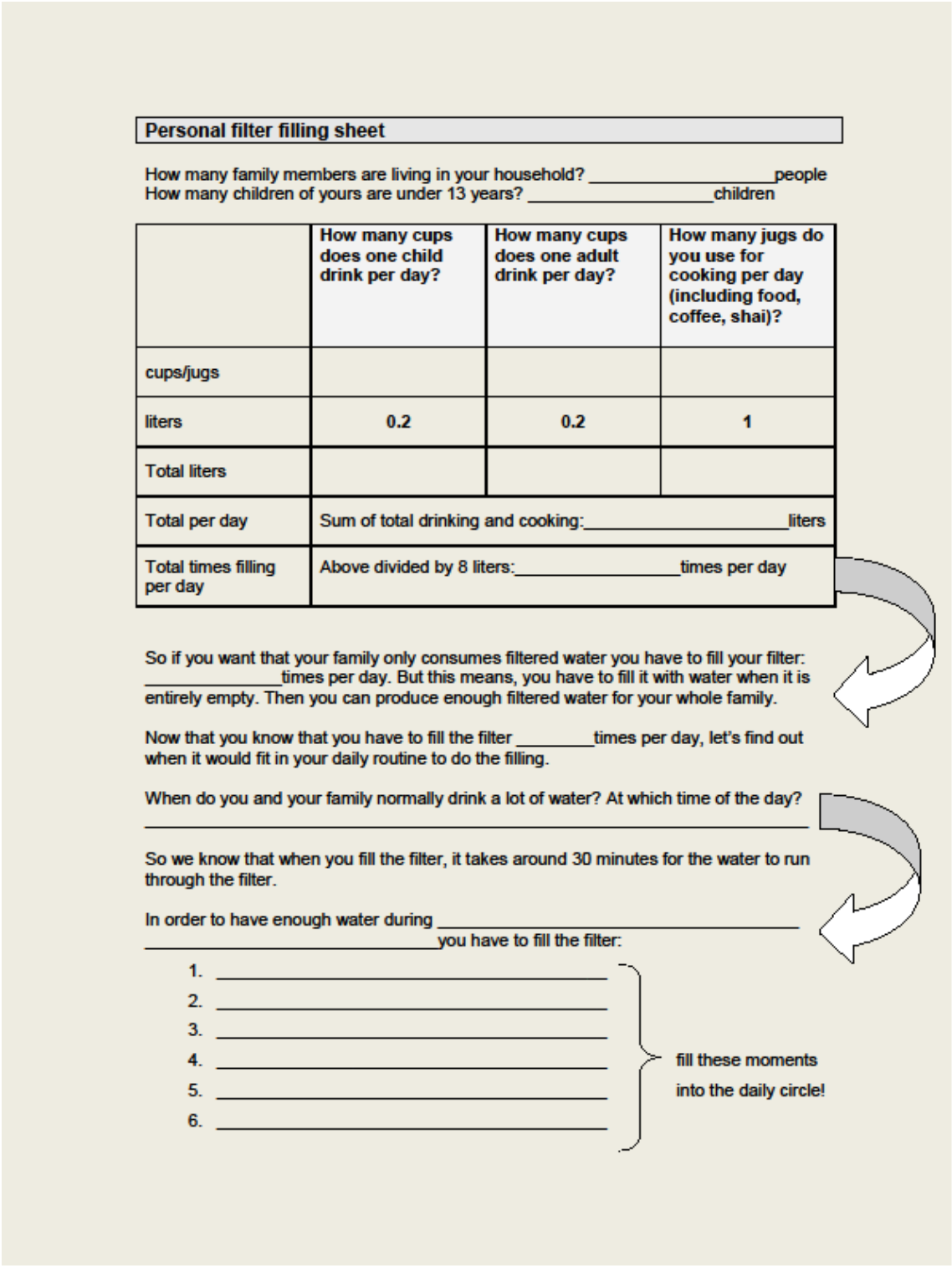
Details on the educational workshop with pledging

An influential and well-regarded woman from the village Weyo Gabriel, where the workshop was held, was trained for two days to be the workshop leader. She was informed about the purpose of the workshop and trained in depth on the content. Detailed scripts were given for the first part of the workshop, the persuasive and informational session, and for the pledging (fig. S4), translated into Amharic and Oromic. Attending women were approached three days prior to the workshop. During the workshop, the woman holding it was assisted by our partner NGO's social worker.

The workshop was scheduled to last three hours and consisted of an initial greeting, followed by a persuasive and informational session, an open discussion, an interactive group game, and participants' pledge to change their behavior in the end. During the greeting attendees were invited to actively participate and to feel free to always ask questions. Then, the workshop leader began with the persuasive and informational part. She first informed participants about the characteristics of fluoride by saying that it was an extremely microscopic chemical, too small to be seen by naked eye, and that it is tasteless; thus, filtered and unfiltered water tastes the same. The next part of the workshop was about fluorosis; she described the illness and showed pictures of affected people. She talked about the incurability of fluorosis, which led her The workshop was scheduled to last three hours and consisted of an initial greeting, followed by a persuasive and informational session, an open discussion, an interactive group game, and participants' pledge to change their behavior in the end. During the greeting attendees were invited to actively participate and to feel free to always ask questions. Then, the workshop leader began with the persuasive and informational part. She When discussions amongst participants started, they were not stopped but encouraged. Discussed topics were, for example, whether injera (the Ethiopian flat bread) tasted better if cooked with filtered or unfiltered water, and whether or not it would be good for

your skin if you washed yourself with filtered water from time to time. In the open discussion, participants were invited to ask questions about the informational part. Next, there was an interactive group game, a knowledge quiz to repeat and consolidate the new knowledge. Participants were divided into five groups, each with four to five women. The task derived from six different multiple choice questions on fluoride, fluorosis, and prevention. The questions were written on large posters in Amharic as well as in Oromic, and participants had to decide whether laminated pictures that symbolized the possible answers belonged to the right or wrong side of the poster. Figure 5 shows a correctly solved task. Before participants were divided into groups, one question had been solved by the whole group as an exercise example (see Fig. S6). Each group was quickly visited to ensure they got their question right and that they understood the meaning of each picture. Afterwards each group presented their solution in front of the plenum where they were corrected if necessary.

In the final pledging portion of the workshop (Fig. S4), the leader asked the participants whether they wanted to commit themselves to always using filtered water for cooking and drinking. All women raised their hands for approval. Subsequently, each woman got up and pledged in front of the plenum. In the end, the workshop leader thanked the women for their participation and they all received financial compensation for their attendance.



Personal filter filling sheet

How many family members are living in your household? _____people
How many children of yours are under 13 years? _____children

	How many cups does one child drink per day?	How many cups does one adult drink per day?	How many jugs do you use for cooking per day (including food, coffee, shai)?
cups/jugs			
liters	0.2	0.2	1
Total liters			
Total per day	Sum of total drinking and cooking:_____liters		
Total times filling per day	Above divided by 8 liters:_____times per day		

So if you want that your family only consumes filtered water you have to fill your filter: _____times per day. But this means, you have to fill it with water when it is entirely empty. Then you can produce enough filtered water for your whole family.

Now that you know that you have to fill the filter _____times per day, let's find out when it would fit in your daily routine to do the filling.

When do you and your family normally drink a lot of water? At which time of the day?
_____

So we know that when you fill the filter, it takes around 30 minutes for the water to run through the filter.

In order to have enough water during _____
_____you have to fill the filter:

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____

fill these moments into the daily circle!

Figure S1. Personal Filling Sheet for the Planning and Social Prompt Intervention.

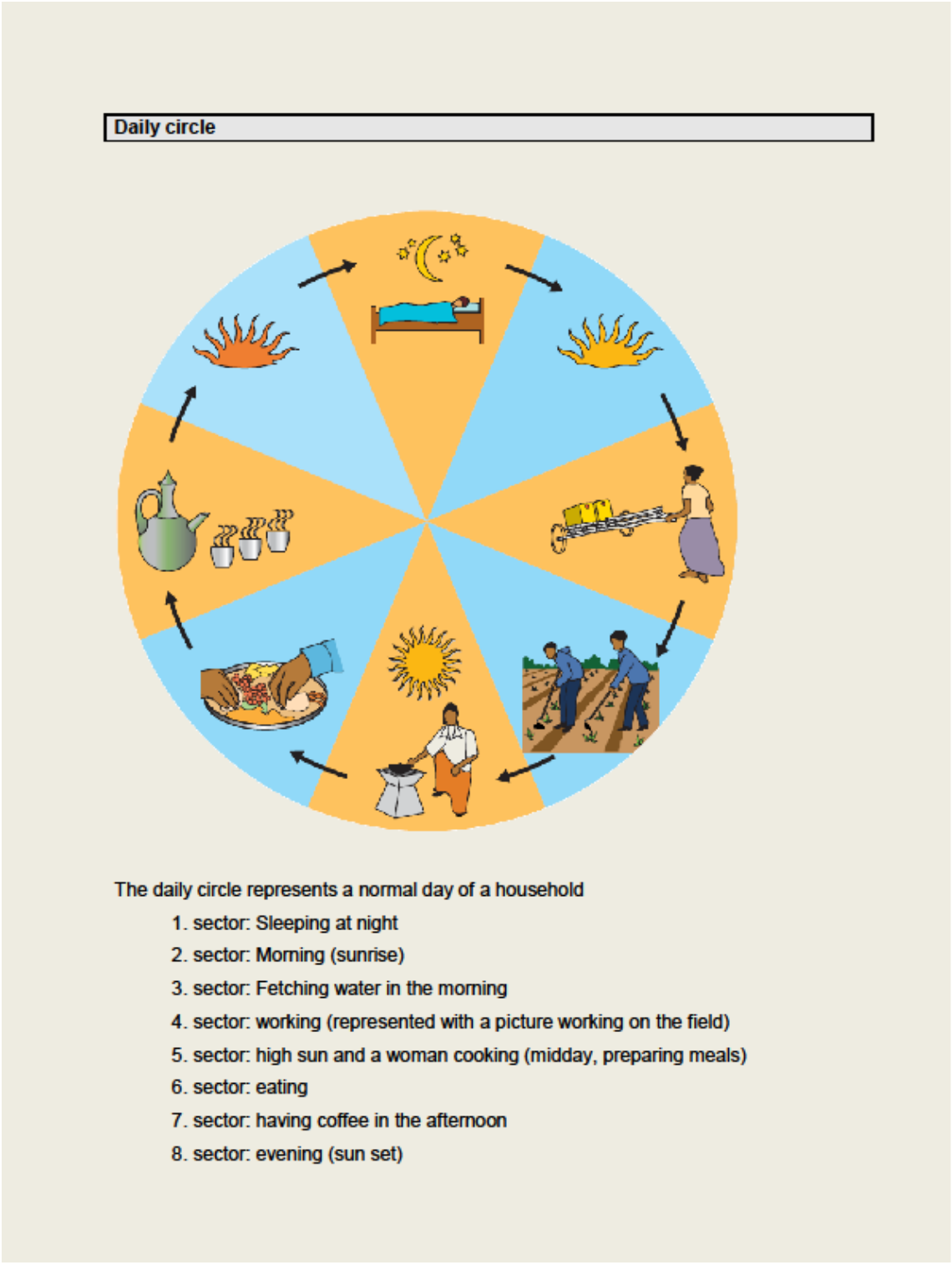
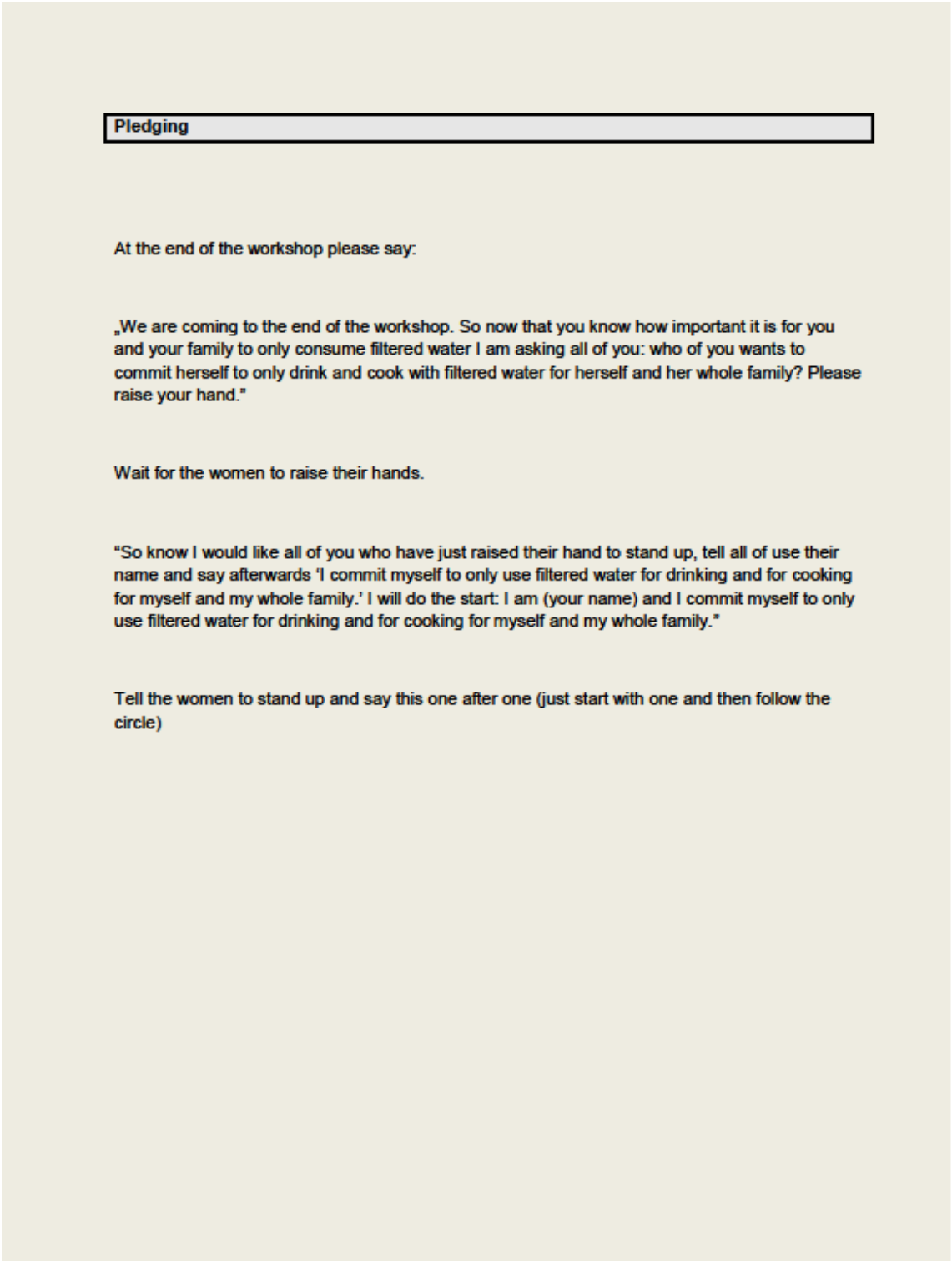


Figure S2. Daily Circle for the Planning and Social Prompt Intervention.



Pledging

At the end of the workshop please say:

„We are coming to the end of the workshop. So now that you know how important it is for you and your family to only consume filtered water I am asking all of you: who of you wants to commit herself to only drink and cook with filtered water for herself and her whole family? Please raise your hand."

Wait for the women to raise their hands.

"So know I would like all of you who have just raised their hand to stand up, tell all of use their name and say afterwards 'I commit myself to only use filtered water for drinking and for cooking for myself and my whole family.' I will do the start: I am (your name) and I commit myself to only use filtered water for drinking and for cooking for myself and my whole family."

Tell the women to stand up and say this one after one (just start with one and then follow the circle)

Figure S3. Instruction for Workshop Leader for the Pledging.

Appendix B: Supporting Information for Study 3

Details on behavior change campaigns

Persuasive intervention on perceived costs

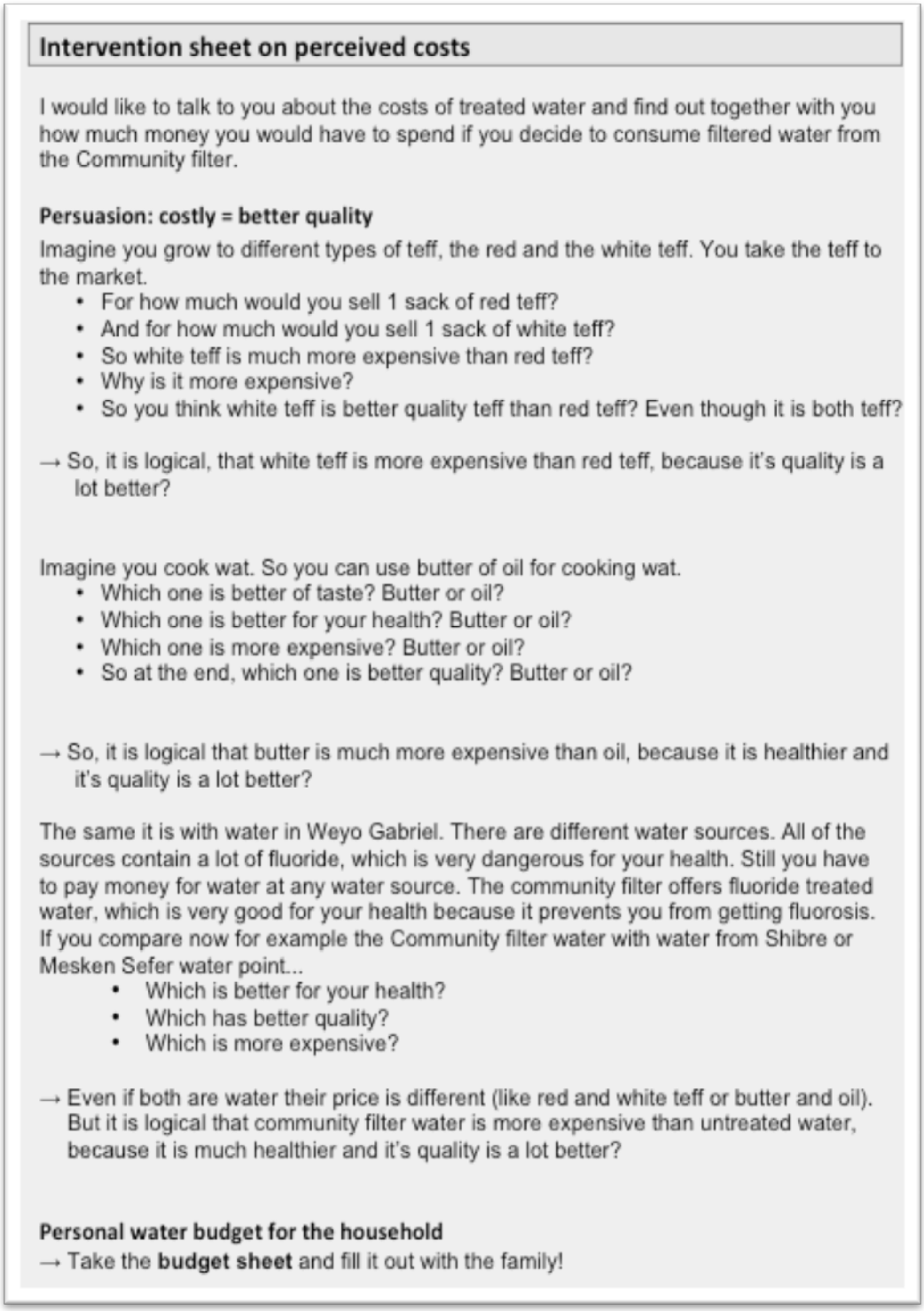
Prior to the intervention phase, ten local health extension workers (promoters) absolved a 3-day training on persuasion techniques and on the content of the promotion. Households assigned to the cost intervention group received a promoter visit, which lasted approximately 30 minutes. The promoter first provided general information on fluoride, fluorosis and the community filter. Additionally, the households received a persuasion on costs. The instructions given to the promoter can be found in Figure S1.

As a next step, the promoter calculated, together with the head of household, a water budget for that particular household. This way, the household got realistic estimates of how much filtered water was required and how much money they would have to spend per week (see Figure S2). After completing the water budget sheet, the promoter asked for questions or concerns about the discussed issue, and at the end thanked and said goodbye.

Persuasive intervention on perceived vulnerability

Households assigned to the vulnerability intervention group received a promoter visit of around 30 minutes including a general information part (information about fluoride, fluorosis and the community filter). Furthermore, these households received persuasion on vulnerability. The instructions given to the promoters are presented in Figure S3. To visualize the information, people were showed on a chart (see Figure S4) how contaminated their raw water source is and, faced with pictures of people suffering from dental and skeletal fluorosis (see Figure S5).

After giving personal risk information for each child, the promoters were instructed to inform the household what they can do about the problem (see Figure S6 and S7).



Intervention sheet on perceived costs

I would like to talk to you about the costs of treated water and find out together with you how much money you would have to spend if you decide to consume filtered water from the Community filter.

Persuasion: costly = better quality

Imagine you grow to different types of teff, the red and the white teff. You take the teff to the market.

- For how much would you sell 1 sack of red teff?
- And for how much would you sell 1 sack of white teff?
- So white teff is much more expensive than red teff?
- Why is it more expensive?
- So you think white teff is better quality teff than red teff? Even though it is both teff?

→ So, it is logical, that white teff is more expensive than red teff, because it's quality is a lot better?

Imagine you cook wat. So you can use butter of oil for cooking wat.

- Which one is better of taste? Butter or oil?
- Which one is better for your health? Butter or oil?
- Which one is more expensive? Butter or oil?
- So at the end, which one is better quality? Butter or oil?

→ So, it is logical that butter is much more expensive than oil, because it is healthier and it's quality is a lot better?

The same it is with water in Weyo Gabriel. There are different water sources. All of the sources contain a lot of fluoride, which is very dangerous for your health. Still you have to pay money for water at any water source. The community filter offers fluoride treated water, which is very good for your health because it prevents you from getting fluorosis. If you compare now for example the Community filter water with water from Shibre or Mesken Sefer water point...

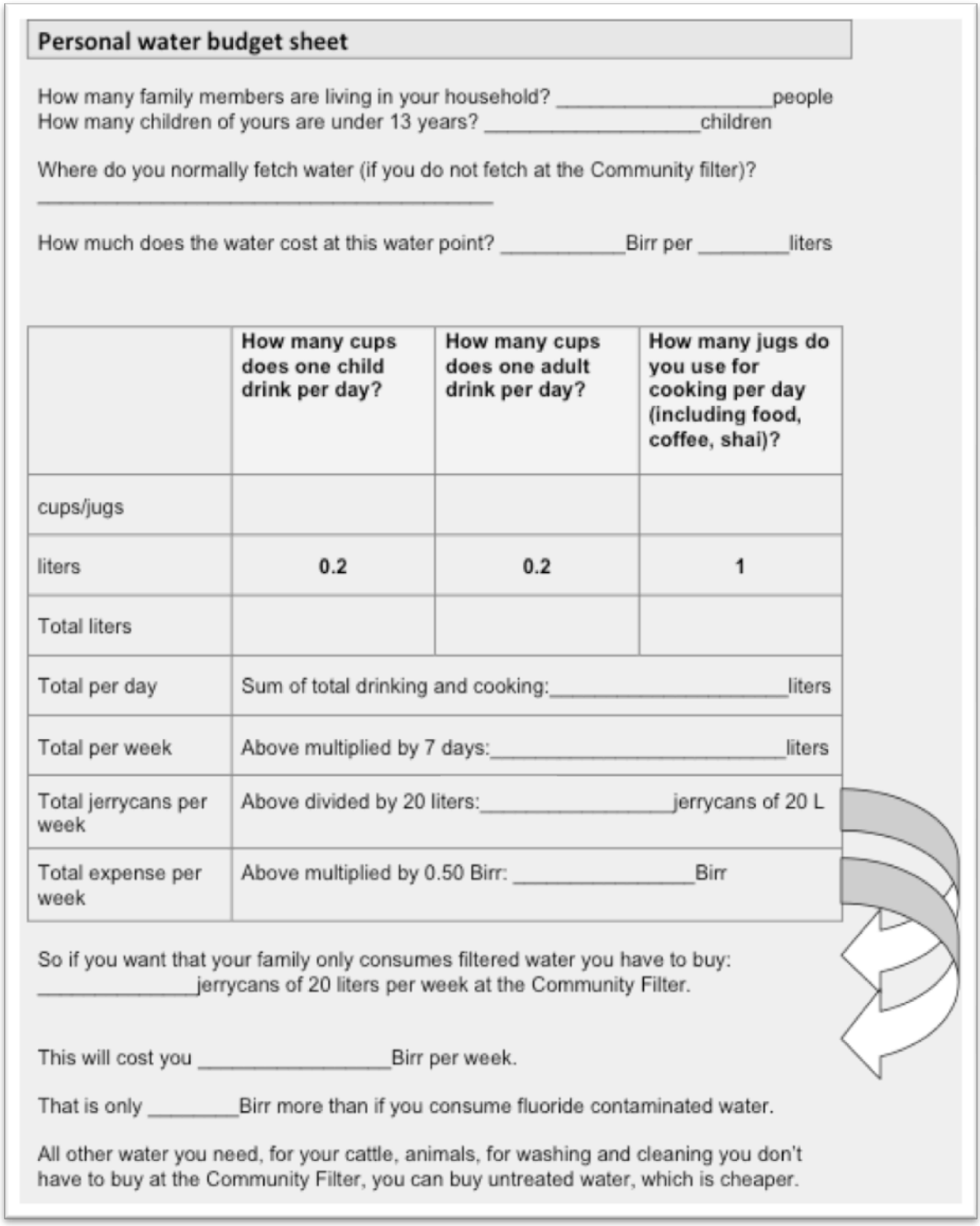
- Which is better for your health?
- Which has better quality?
- Which is more expensive?

→ Even if both are water their price is different (like red and white teff or butter and oil). But it is logical that community filter water is more expensive than untreated water, because it is much healthier and it's quality is a lot better?

Personal water budget for the household

→ Take the **budget sheet** and fill it out with the family!

Figure S1. Instruction for promoters for cost persuasion.



Personal water budget sheet

How many family members are living in your household? _____people
How many children of yours are under 13 years? _____children

Where do you normally fetch water (if you do not fetch at the Community filter)?
_____

How much does the water cost at this water point? _____Birr per _____liters

	How many cups does one child drink per day?	How many cups does one adult drink per day?	How many jugs do you use for cooking per day (including food, coffee, shai)?
cups/jugs			
liters	**0.2**	**0.2**	**1**
Total liters			
Total per day	Sum of total drinking and cooking:_____liters		
Total per week	Above multiplied by 7 days:_____liters		
Total jerrycans per week	Above divided by 20 liters:_____jerrycans of 20 L		
Total expense per week	Above multiplied by 0.50 Birr: _____Birr		

So if you want that your family only consumes filtered water you have to buy:
_____jerrycans of 20 liters per week at the Community Filter.

This will cost you _____Birr per week.

That is only _____Birr more than if you consume fluoride contaminated water.

All other water you need, for your cattle, animals, for washing and cleaning you don't have to buy at the Community Filter, you can buy untreated water, which is cheaper.

Figure S2. Personal water budget sheet for individual households.

Intervention sheet on children's vulnerability

Water source

- From which water source do you normally get your water from for drinking and cooking?
- Do your children drink from this water?
- Do your children eat food cooked with this water?

→ Show the water sources fluoride chart!
→ Show them where they are!

Children

- How many children do you have?
- What are their names? How old are they? (Girls or boys or both?)
- Make notes on your notebook.
- If the children are around ask to be introduced to them!

Name	Age

Personal Risk Information

For every child you have to speak out a personal risk information.
E.g.:
"Your daughter _____ is now 4 years old. She is consuming since 4 years water from _____ water source, which is contaminated with fluoride. If she will continue to consume water from this source the probability is very high that she will be crippled within in few years. Do you really want to put your daughter at that risk? Seble can lead a normal and healthy life if she starts now to consume fluoride free water."

"If your daughter _____ (always name the girl to make it more personal) continuous to drink untreated water she will be crippled and that means that:

- she will be always dependent on her family,
- she will not be able to work,
- she will have problems finding a husband,
- she will have problems to receive children,
- she will be socially excluded and
- she will not be able to have a normal job or to be a good housewife.

"If your son _____(name the boy to make it more personal) continuous to drink untreated water he will be crippled within few years and that means that:

- he will be always dependent on his family,
- he will not be able to work,
- he will have problems finding a wife,
- he will have problems to have children,
- he will be socially excluded and
- he will not be able to make his own money

→ Show them the pictures of fluorosis!

Figure S3. Instructions for promoters for vulnerability persuasion.

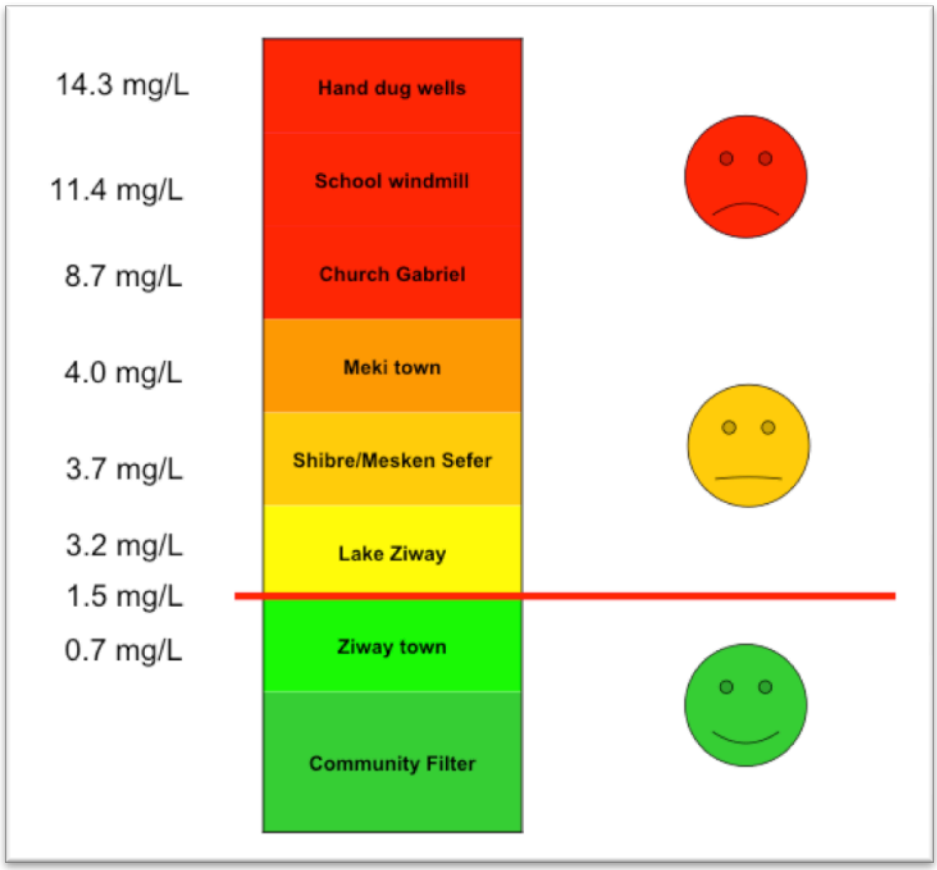


Figure S4. Water sources fluoride chart indicating grade of contamination of each accessible source in the village.

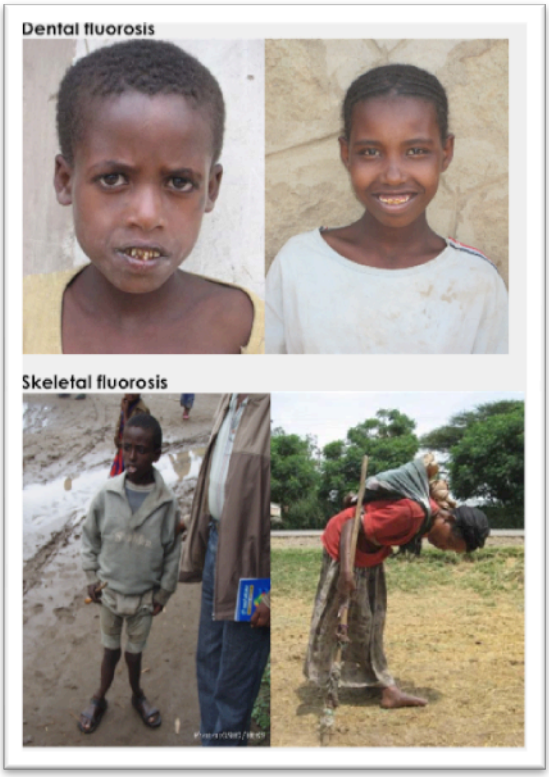


Figure. S5. Pictures of people suffering from dental and skeletal fluorosis.

You as a parent, you can do something for your children's (name them) future!!!

What can you do?

The less you and your children drink fluoride contaminated water and the less they eat food cooked with untreated water, the less they are at risk getting dental and skeletal fluorosis!

→ Show them the graph! (Risk of getting fluorosis)

"This could be your daughter/son after some years if she/he continues to drink water from _____(raw water source)." → show them the picture of crippled women

"But if they stop consuming untreated water know, they will be healthy and not crippled!" → show them the picture the smiling boy

The community filter offers fluoride treated water. If you fetch water there and give to your children for drinking than their risk will be much lower to be affected by skeletal fluorosis. Also you should always cook your food (wat, injera), coffee and shai with filtered water from the community filter.

Give your children (name them) a healthy future!! Don't put them at risk of getting fluorosis!

Figure S6. Instructions for promoters for information about prevention of fluorosis.

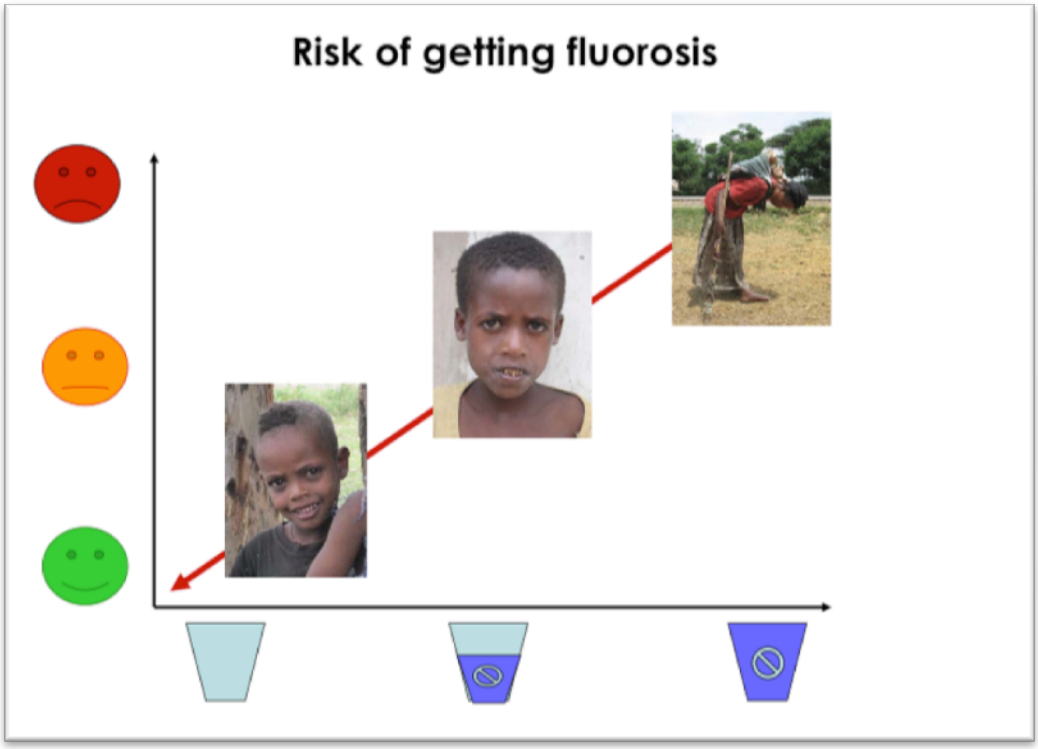


Figure S7. Risk graph showing the risk of getting fluorosis.

Questionnaires

The questionnaires covered the use of the community filter, household consumption of fluoride-free water, and all psychological factors described in the introduction section of the article.

Operationalization

In the table below (see Table S1) all items for operationalizing the different factors are compiled. The table also includes the response options and the corresponding values used in the analyses.

Table S 1: Factors, items and response options with corresponding values.

Factors	Items	Response options	Values
Behavior	Interviewer estimation of vessels used for drinking and pouring for cooking	open	
	How many cups do your children/you adults drink in total /from the filter/from rainwater/from other water per day?	open	
	How many jugs do you use for cooking per day in total/from the filter/from rainwater/from other sources?	open	
	How many jerrycans/barrels of water do you fetch at the community filter per week?	open	
Risk factors			
Vulnerability	How high or low do you feel are the chances that you get skeletal fluorosis? My chance is…	5-point scale from much higher than average to much lower than average	-4 to 4
	How high or low do you feel are the chances that someone of your family develops skeletal fluorosis? The chances are…	5-point scale from much higher than average to much lower than average	-4 to 4
	How high or low do you feel are the chances that someone of your family develops dental fluorosis? The chances are…	5-point scale from much higher than average to much lower than average	-4 to 4
Severity	Imagine that you contracted dental/skeletal fluorosis, how severe would be the impact on your life in general?	5-point scale from not severe at all to very severe	0 to 4
	Imagine that you contracted dental/skeletal fluorosis, how severe would be the impact on your social life?	5-point scale from not severe at all to very severe	0 to 4
	Imagine that you contracted dental/skeletal fluorosis, how severe would be the impact on your economic situation?	5-point scale from not severe at all to very severe	0 to 4
Knowledge	What are the symptoms of fluorosis?	Skeletal deformation (yes/no) Diarrhea (yes/no) Coloured teeth (yes/no) Head ache (yes/no)	For each 0 or 1
	What causes coloured teeth?	Untreated water (yes/no) Coffee (yes/no) Water from Lake (yes/no) Fluoride (yes/no)	For each 0 or 1
	What causes deformed bones?	Malaria (yes/no) Untreated water (yes/no) Renal problem (yes/no) Fluoride (yes/no)	For each 0 or 1
	What is fluoride?	A chemical (yes/no) A parasite (yes/no) A worm (yes/no) A stone (yes/no)	For each 0 or 1
	How can you prevent getting fluorosis?	With boiling the water before consuming it (yes/no) With filtering the water before consuming it (yes/no) With taking medicine (yes/no) With brushing your teeth more often (yes/no)	For each 0 or 1
Attitude factors			

Overall affective belief	How pleasant or unpleasant is it for you to consume filtered water?	9-point scale from very unpleasant to very pleasant	-4 to 4
	How much do you like or dislike consuming filtered water?	9-point scale from I dislike it very much to I like it very much	-4 to 4
Overall instrumental belief	How positive or negative do you think is it to consume filtered water?	9-point scale from very negative to very positive	-4 to 4
	Do you think consuming filtered water is necessary or unnecessary?	9-point scale from very unnecessary to very necessary	-4 to 4
Health impact	Do you think that drinking filtered water is good or bad for your health?	9-point scale from very unhealthy to very healthy	-4 to 4
Taste	How much do you like or dislike the taste (drinking) of filtered water?	9-point scale from I dislike it very much to I like it very much	-4 to 4
	How much do you like or dislike the taste of food cooked with filtered water?	9-point scale from I dislike it very much to I like it very much	-4 to 4
	How much do you like or dislike the taste of coffee cooked with filtered water?	9-point scale from I dislike it very much to I like it very much	-4 to 4
	How much do you like or dislike the color of food cooked with filtered water?	9-point scale from I dislike it very much to I like it very much	-4 to 4
Perceived costs	Do you think that 0.5 Birr for one 20 liter jerrycan of fluoride free water is too cheap, too expensive, or right?	9-point scale from much too expensive to much too cheap	-4 to 4
Normative factors			
Subjective norm	Do you think that, over all, your relatives rather (dis)approve that you fetch water at the community filter?	9-point scale from very strong disapproval to very strong approval	-4 to 4
	Most of my relatives think I should fetch water at the community filter.	9-point scale from I strongly disagree to I strongly agree	-4 to 4
	Most of my relatives support me in fetching water at the community filter.	9-point scale from I strongly disagree to I strongly agree	-4 to 4
	Most of my neighbours think I should fetch water at the community filter.	9-point scale from I strongly disagree to I strongly agree	-4 to 4
	Most of my neighbours support me in fetching water at the community filter.	9-point scale from I strongly disagree to I strongly agree	-4 to 4
Descriptive norm	How many people from your kebele (community) fetch water at the community filter?	5-point scale from almost nobody to almost all	0 to 4
	How many of your relatives (excluding people living in your household) fetch water at the community filter?	5-point scale from almost nobody to almost all	0 to 4
	How many of your neighbours fetch water at the community filter?	5-point scale from almost nobody to almost all	0 to 4
Personal norm	I am willing to put extra effort into fetching water at the community filter on a regular basis.	9-point scale from I strongly disagree to I strongly agree	-4 to 4
	I feel a strong personal obligation to fetch water at the community filter.	9-point scale from I strongly disagree to I strongly agree	-4 to 4
	I would feel guilty if I didn't fetch water at the community filter.	9-point scale from I strongly disagree to I strongly agree	-4 to 4
Guest norm	How important is it for you to present filtered water to your guests?	5-point scale from not important at all to very important	0 to 4

Ability factors			
Perceived behavioral control	How often do you need more water for drinking and cooking than is available from the filter?	5-point scale from almost always to almost never	0 to 4
Self-efficacy	Various barriers make it hard to fetch water at the community filter. I am sure that I can fetch as much water as I need within the next year.	9-point scale from I strongly disagree to I strongly agree	-4 to 4
	I am confident that I can save enough money to buy enough water from the community filter.	9-point scale from I strongly disagree to I strongly agree	-4 to 4
	I am able to fetch enough water for the whole family at the community filter.	9-point scale from I strongly disagree to I strongly agree	-4 to 4
	I believe I have the ability to fetch water at the community filter regularly in the next month.	9-point scale from I strongly disagree to I strongly agree	-4 to 4
Self-regulation factors			
Commitment	How important is it for you to fetch water at the community filter regularly?	5-point scale from not important at all to very important	0 to 4
	Do you feel committed to fetch water at the community filter?	5-point scale from not committed at all to very committed	0 to 4
	How annoyed do you feel if you forget to fetch water at the community filter?	5-point scale from not annoyed at all to very annoyed	0 to 4
Perceived habit	How much do you feel that you fetch water at the community filet as a matter of habit?	5-point scale from not at all a habit to a very strong habit	0 to 4
Automaticity	I fetch water at the community filter automatically without thinking much about it.	9-point scale from I strongly disagree to I strongly agree	-4 to 4
Forgetting	How often does it happen that you forget to fetch water at the community filter?	5-point scale from almost always to almost never	-4 to 4

Baseline Results

Table S2. Means and standard deviations for each group during baseline.

	CTRL	COST FIT	COST MISFIT	VUL FIT	VUL MISFIT
Gender	.64	.53	.78	.77	.91
	(.48)	(.51)	(.41)	(.43)	(.30)
Age	33.78	38.89	31.00	33.35	39.18
	(14.68)	(15.59)	(12.20)	(10.27)	(19.30)
Behavior	76.28	49.2	71.67	69.54	89.9
	(27.76)	(35.48)	(34.1)	(36.78)	(17.37)
Vulnerability	-0.51	-0.53	0.44	0.54	-1.58
	(2.79)	(2.62)	(2.52)	(3.22)	(2.28)
Severity	3.85	3.7	3.81	3.92	3.91
	(.31)	(0.42)	(0.38)	(0.24)	(0.16)
Knowledge	2.96	2.73	3.67	2.77	2.64
	(1.08)	(1.08)	(0.97)	(1.05)	(0.87)
Overall affective belief	3.48	3.3	3.61	3.70	3.64
	(.59)	(1.45)	(0.49)	(0.46)	(0.5)
Overall instrumental belief	3.51	3.18	3.67	3.73	3.73
	(.60)	(1.51)	(0.35)	(0.38)	(0.41)
Health impact	3.53	3.3	3.67	3.77	3.64
	(.59)	(1.49)	(0.5)	(0.51)	(0.67)
Taste	2.46	2.03	3.25	3.00	2.7
	(1.31)	(2.14)	(0.56)	(1.58)	(0.97)
Perceived costs	-1.45	-3.37	3.11	-2.19	-0.36
	(2.41)	(0.72)	(0.78)	(1.58)	(0.51)
Subjective norm	2.83	2.81	3.11	3.00	3.51
	(1.15)	(1.66)	(0.81)	(1.55)	(0.63)
Descriptive norm	1.72	2.09	1.56	1.65	1.61
	(.78)	(0.85)	(0.73)	(0.7)	(0.49)
Personal norm	2.91	2.82	3.44	3.29	3.3
	(.94)	(1.56)	(0.53)	(0.97)	(0.66)
Guest norm	3.75	3.87	3.89	3.73	3.82
	(.49)	(0.35)	(0.33)	(0.53)	(0.41)
Perceived behavior control	2.06	1.80	2.00	2.23	2.64
	(1.40)	(1.54)	(1.5)	(1.51)	(1.206)
Self-efficacy	2.22	2.48	3.28	2.79	3.34
	(1.82)	(1.47)	(0.51)	(1.09)	(0.52)
Commitment	2.91	3.01	3.33	3.21	3.45
	(.94)	(0.95)	(0.55)	(0.98)	(0.4)
Perceived habit	2.88	2.67	3.61	3.29	3.23
	(1.06)	(1.46)	(0.42)	(0.76)	(0.68)
Automaticity	0.62	0.72	0.89	1.71	1.77
	(2.82)	(3.08)	(3.36)	(2.65)	(2.83)
Forgetting	0.80	0.67	0.44	0.46	0.73
	(1.21)	(1.16)	(1.33)	(0.81)	(1.27)

Note: Means and standard deviations in brackets. The gender item is coded as 0=male, 1=female.

CURRICULUM VITAE

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PERSONAL INFORMATION

Date of Birth	5 August 1981
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EDUCATION

2009 to 2012	PhD Candidate *at* the Swiss Federal Institute of Aquatic Science & Technology (Eawag) and the University of Zurich, Switzerland **Degree: PhD in Psychology** *Thesis title: Increasing and Stabilizing Safe Water Consumption with Behavior Change Campaigns: A Field Study in Rural Ethiopia*
2002 to 2009	Studies in Psychology, Psychopathology and English Literature, University of Zurich, Switzerland **Degree: Master of Science in Psychology** *Thesis title: The Modes of Operation of Prompts and Public Commitment: A Field Study in Bolivia*

WORK EXPERIENCE

2009 to 2012	Eawag, Switzerland and Ethiopia Project: Optimization and Acceptance of fluoride removal options for drinking water in rural Ethiopia *PhD and Project Coordinator of the Social Research Team*
2005 to 2009	Hubrol AG, Altdorf, Switzerland *Translator English-German*
2007	Center for Addictive Disorders, Psychiatric University Clinic of Zurich, Switzerland *Intern*
2006	Eawag, Switzerland and Bolivia Project: Safe Drinking Water and Clean Hands, Chuquisaca, Bolivia *Assistant Project Coordinator and Research Collaborator*
2005	Market Research Institution LINK, Switzerland *Interviewer*

OTHER ACTIVITIES

2010 to 2012 Ombudsperson for PhD Candidates at Eawag, Switzerland

2006 to 2008 Tutor for Psychology Students at the University of Zurich, Switzerland

SKILLS

Management

- Advanced project management skills, above all for research projects in developing countries. Including recruitment and leadership of several employees (interviewers, health workers, research assistants and social workers), management of budget and finances.
- Excellent time management skills.

Collaborations

Interdisciplinary research and project collaboration with governmental and non-governmental organizations:

- Swiss Interchurch Aid (HEKS), Switzerland and Ethiopia
- University of Addis Ababa, Ethiopia
- Oromo Self Help Organization (OSHO), Ethiopia
- Fundacion SODIS, Bolivia
- Ministry of Health and Departmental Health Service, Bolivia

Research

- Quantitative data analysis
- Cross-sectional and longitudinal data analysis
- Effectiveness of health promotion campaigns
- Designing evidence-based behavior change campaigns

Teaching

- Assistance of Prof. Dr. Mosler in several seminars at the University of Zürich
- Supervision of several Master's theses

Languages

- German (native)
- English (advanced)
- Spanish (advanced)
- French (intermediate)
- Amharic (basic)

Computer

- Microsoft Office
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REFERENCES

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More references on request

PUBLICATIONS

Scientific journals

Huber, A.C., Bhend, S., & Mosler, H.-J. (2011). Determinants of exclusive consumption of fluoride-free water: a cross-sectional household study in rural Ethiopia. *Journal of Public Health*, 20, 269-278.

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Talks

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Huber, A.C. (2011). Public health interventions to enhance the consumption of safe drinking water in rural Ethiopia. Paper presented at the 25th European Health Psychology Conference, Crete, Greece.

Mosler, H.-J., Huber, A.C., & Bhend, S. (2011). Behavioral determinants of using fluoride removal filters in rural Ehtiopia. Paper presented at the 35th WEDC International Conference, Loughborough, UK.

Huber, A.C., & Mosler, H.-J. (2010). The consumption of fluoride free drinking water using filters in rural Ethiopia. Paper presented at the 27th International Congress of Applied Psychology, Melbourne, Australia.

Huber, A.C., & Mosler, H.-J. (2009). The modes of operation of prompts and public commitment: results of a field study in Bolivia. Paper presented at the 8th Biennial Conference of Environmental Psychology, Zürich, Switzerland.

Poster presentations

Huber, A.C., Tobias, R., & Mosler, H.J. (2012). Stabilizing a behavior in spite of an unsustainable alternative: fluoride-safe water consumption in Ethiopia. Poster presented at the 26th European Health Psychology Conference, Prague, Czech Republic.

Huber, A.C., Röösli, Z., & Mosler, H.-J. (2011). Fluoride contaminated water as an environmental health treat: changing people's water consumption in rural Ethiopia. Poster presented at the 12th Swiss Global Change Day, Bern, Switzerland.

Tamas, A., Huber, A.C., & Mosler, H.-J. (2008). Promotion of SODIS using psychological behavior change strategies. Poster presented at the International Conference on Research for Development, Bern, Switzerland.